SEVENTH EDITION

Techniques of

CRIME SCENE INVESTIGATION

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Techniques of CRIME SCENE INVESTIGATION

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with a foreword by
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Dedication

This book is dedicated to the unsung heroes of the criminal justice system — those men and women who through the application of science and technology bring criminals to justice and protect those wrongfully accused.

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Foreword

Forensic science has been an ally of law enforcement agencies for decades. That relationship has grown even stronger with the startling new advancements in science and technology. Law enforcement agencies throughout the world rely heavily on forensic science to assist in solving the most complex crimes while sorting out elaborate crime scenes. To an untrained eye, many of these crime scenes appear to contain little or no evidence. However, upon closer inspection by these highly skilled, trained professionals, unseen evidence — hair, skin, bodily fluids, microscopic fibers, and traces of seemingly insignificant items are revealed as important pieces of the puzzle. The long arm of the law becomes even longer in large measure because of the dedication and commitment of these forensic professionals.

Needless to say, law enforcement owes a debt of gratitude to the forensic professionals working on our team. We enjoy a very productive relationship with experts in all the areas of forensic science and crime scene investigations: fingerprint identification, forensic photography, questioned documents, firearms, toxicology, narcotics analysis, forensic DNA testing, and trace evidence examination.

The Los Angeles County Sheriff's Department has been especially fortunate to have Barry A.J. Fisher as the director of our Scientific Services Bureau, one of the largest municipal crime laboratories in the nation. I am honored to offer this brief commentary for his latest publication, the seventh edition of *Techniques of Crime Scene Investigation*. His unfettered and candid pledge to the field of forensic science is evident in this latest edition. This volume also highlights some of the latest techniques of forensic science and discusses our latest concerns in handling potential terrorism crime scenes that may contain chemical or biological agents and evidence.

The Los Angeles County Sheriff's Department is fortunate to have leaders like Barry Fisher, who consistently strives to initiate advancements in his areas of expertise and educate others to radiate the same commitments and traditions.

Leroy D. Baca
Sheriff of Los Angeles County

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Preface

Readers may ask why I wrote a new edition; after all, crime scene investigation is a static field with few changes. True enough. There have been DNA advances and other developments in forensic science. However, new practitioners and students of crime scene investigations and forensic science must be aware of two increasingly important issues: increasing judicial reviews of science and technology in the courtroom and the specter of terrorism and weapons of mass destruction with which first responders, forensic scientists and medical examiners will be faced. September 11, 2001, has shown us that the unthinkable is indeed possible.

Having said all this, criminal investigations remain a complex undertaking and require professionals from many disciplines to work cooperatively toward one common goal. The effective use of science and technology is a critical element to crime solving. Police investigators and prosecutors must be able to use this resource to its full potential.

Science and technology applied to the solution of criminal acts — forensic science — solve crimes and potentially save lives. Scientific crime scene investigation aids police investigators in identifying suspects and victims of crimes, clearing innocent persons of suspicion and ultimately bringing the wrongdoers to justice. When the justice system is able to remove a criminal from society, innocent persons do not become new victims of criminal acts.

This book is about the proper and effective use of science and technology in support of the police. The seventh edition of *Techniques of Crime Scene Investigation* is written for students of crime scene investigation, police investigators, crime scene technicians, and forensic scientists. The material presented in this text is basic, covering the proper ways to examine crime scenes and collect a wide variety of physical evidence that may be encountered at crime scenes. It cannot cover every possible situation and is a guide. The areas are discussed in general terms in order to give the reader some idea of the information that can be developed from physical evidence if it is collected properly. Few of the procedures mentioned in the book are inviolable.

Techniques of Crime Scene Investigation is a classic book on how to use forensic science to investigate crimes. The text was first published in Swedish in 1949 by Chief Superintendent Arne Svensson, director of the Laboratory, Criminal Investigation Department, and Superintendent Otto Wendel, Criminal Investigation Department, Stockholm, Sweden. In 1955 it was printed in English as *Crime Detection* and then revised into a second, expanded American Edition under the title *Techniques of Crime Scene Investigation* in 1965. In 1981 I was invited to revise it in a third edition and subsequently into fourth, fifth, and sixth editions. This seventh edition is the fifth revision I have had the privilege to write.

The latest edition of *Techniques of Crime Scene Investigation* continues a half-century tradition of providing useful techniques, procedures and suggestions on how to locate, document, collect and process physical evidence associated with criminal acts. This edition

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continues in that tradition. It updates some of the new areas in the field and covers some new topics while keeping intact those areas that have not changed greatly. I have also added some new photographs to illustrate certain areas of the text.

Some of the topics included in this edition include:

- Discussion on professional ethics
- Challenges facing forensic science laboratories and suggestions for addressing them
- Expert witness testimony
- Health and safety issues at crime scenes
- Forensic DNA testing
- Forensic databases
- Elder abuse
- Forensic science and terrorist acts

Another feature new to this edition is a companion CD developed by Dr. Jane Homeyer and Sarah Mikolajczyk: CAT^3, Creative Approaches to Teaching, Training & Testing, Inc. This new concept of a traditional textbook with a CD that mirrors the major topics represents a 21st century approach to learning that we hope is seen as a big plus for our readers. The CD can be purchased directly from CRC Press.

The use of forensic science in criminal investigations depends on a number of factors. Police investigators must be knowledgeable about the capabilities of the forensic science support services available to them and appreciate how to use them effectively. Forensic practitioners must be familiar with police investigative procedures, the science that supports their own activities, and the legal aspects needed to get the information from the scene and in the lab to the jury. Prosecutors must understand the scientific and technological issues of the case and be able to work with the expert in order to admit expert testimony into court. Police agencies that run forensic science labs must fund them at an appropriate level to ensure quality, reliable, and timely service to the criminal justice system. All of these efforts require the cooperation and willingness of different professionals within the criminal justice system to work well together. Those of us who apply science and technology to the solution of crimes have a duty to do our best for the criminal justice system we serve.

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Acknowledgments

In preparation of this seventh edition, I contacted colleagues for interesting cases for inclusion in it. Although I was not able to use all of their submissions, I want to thank all who responded to my request for cases for this edition. If I have failed to include you in this listing, I apologize for the oversight:

Don Keir, John Shaw, Roger Yung, Mike Havstad, and Yvette Stewart, Scientific Services Bureau, Los Angeles County Sheriff's Department, Los Angeles, CA; Pam Hofsass, Inspector, San Francisco Police Department, Forensic Services Division, San Francisco, CA; Ray Wickenheiser, Laboratory Director, and Doug Lancon, Acadiana Criminalistics Laboratory, New Iberia, LA; Ted Silenieks, Evidence Recovery Section, and Hilton Kobus, Laboratory Director, South Australia Forensic Science Centre, Adelaide, South Australia; Sgt. Paul Sheldon, Crime Scene Investigator, South Australian Police, Adelaide, South Australia; Rick Mancilla, Limbic Systems Inc., Bellingham, WA; C. Michael Bowers, DDS, JD, Ventura, CA; Neil Holland; Forensic Document Examiner, Melbourne, Victoria, Australia; Baruch Glattstein, Division of Identification and Forensic Science, Israel National Police, Jerusalem, Israel; Norman D. Sperber, DDS, San Diego, CA; S.C. Leung, Director, Government Laboratory, Hong Kong.

I also wish to thank my many friends and colleagues who submitted cases and photographs for prior editions of this book. Many of these are shown again in this edition; acknowledgements for those submissions were made in past editions.

I wish to acknowledge the kind support of the Los Angeles County Sheriff's Department and, particularly, Sheriff Leroy D. Baca. During my long career in forensic science, I have been able to take an active part in contributing to the development of forensic science in the U.S. That effort would not be possible without the enlightened support of Sheriff Baca and the other executives in the Sheriff's Department and County of Los Angeles.

I'd like to acknowledge the work of Dr. Jane Homeyer and Sarah Mikolajczyk in developing a companion CD for this book (available from CRC Press). I suspect that their efforts will greatly complement the learning process.

Special thanks are in order to my publisher and editor at CRC Press, Becky McEldowney and Erika Dery, respectively, who were exceedingly patient with me while I was completing the manuscript as well as providing help and encouragement in this effort.

And, finally, thanks to my wife, Susan, who enjoys reminding me that behind every man is a great woman. Susan was a continued source of encouragement to complete the seventh edition of this book.

Barry A. J. Fisher
Los Angeles, California

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The Author

Barry A. J. Fisher grew up in New York City. He received a Bachelor of Science degree in chemistry from the City College of City University of New York in 1966, followed in 1969 by a Master of Science degree in organic chemistry from Purdue University. He also holds an M.B.A. degree from California State University, Northridge, which was awarded in 1973.

In 1969, Fisher joined the Los Angeles County Sheriff's Department Crime Laboratory. He worked in most of the sections of the laboratory and supervised the Trace Evidence and Toxicology Sections. In 1987, he was appointed Crime Laboratory Director. This crime laboratory is one of the largest municipal laboratories in the U.S. A staff of over 200 people is involved in crime scene investigations, fingerprint identification, photography, polygraph, questioned documents, firearms, toxicology, narcotics analysis, forensic biology, forensic DNA testing, and trace evidence examination. Cases run from straightforward blood alcohol tests to complex serial murder investigations, as well as every other imaginable type in between, and employee drug testing. The laboratory routinely processes thousands of criminal cases each year and is accredited by the American Society of Crime Laboratory Directors/Laboratory Accreditation Board.

The laboratory is located near downtown Los Angeles and also operates three regional laboratories in West Covina, Lynwood, and Lancaster. Crime lab services are provided to all law enforcement agencies in Los Angeles County.

Fisher has been working with the Sheriff's Department, the Los Angeles Police Department, the California Department of Justice, and California State University, Los Angeles, to build a state of the art working–teaching forensic science laboratory on the California State Los Angeles campus.

Fisher is a member of several professional organizations. He is a past president of the American Society of Crime Laboratory Directors and a past chairman of the American Society of Crime Laboratory Directors/Laboratory Accreditation Board. He is a Distinguished Fellow and past president of the American Academy of Forensic Sciences. He is past president of the International Association of Forensic Sciences and hosted the 15th triennial meeting of the IAFS on the campus of UCLA in 1999. He serves on the Board of Directors of the National Forensic Science Technology Center, which provides continuing education in forensic science nationwide, and represents the American Academy of Forensic Sciences in the Consortium of Forensic Science Organizations. He has served on a variety of committees including the NIJ-sponsored Technical Working Group on Forensic Science Education and Training (TWGED), the AAFS Forensic Education Programs Accreditation Committee (FEPAC), and the American Bar Association, Criminal Justice Section's Ad Hoc Innocence Committee to Ensure the Integrity of the Criminal Process.

Fisher's textbook, *Techniques of Crime Scene Investigation*, is in its seventh edition and enjoys wide popularity. An international speaker, he has lectured in Canada, England, Australia, Singapore, France, Israel, Japan, and the People's Republic of China on forensic

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science laboratory management practices, quality assurance, and related forensic science topics. He is also a part-time lecturer at UCLA Extension in the Department of the Sciences and the Department of the Arts, Writer's Program.

Fisher and his wife Susan live in a suburb of Los Angeles.

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"We have learned the lesson of history, ancient and modern, that a system of criminal law enforcement which comes to depend on the 'confession' will, in the long run, be less reliable and more subject to abuses than a system which depends on extrinsic evidence independently secured through skillful investigation."

***Escobedo v. Illinois*, 378 U.S. 478, 488–489 (1964)**

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Prologue

September 11, 2001, marked an entirely new set of issues for forensic investigators to consider. Beyond the traditional tasks forensic scientists must perform during criminal investigations, they now have a set of added concerns. Since September 11, first responders and laboratory personnel have been called on to identify victims in mass casualties, as was the case in New York City, the Pentagon and in the fields of western Pennsylvania. Investigators have been required to handle anthrax-tainted physical evidence and are wary about future possibilities of contaminated evidence. One of the newer terms in the aftermath of 9/11 is bioforensics — determining the source of diseases in terrorist acts. Another term new to forensic science is WMD — weapons of mass destruction. These may consist of chemical, biological, nuclear and radiological materials that become part of crime scenes and the evidence associated with crime scenes. Forensic practitioners will need to be knowledgeable about all sorts of new areas in the public health, terrorist and military realms that they have never had occasion to think about before.

In the post September 11 world a fair question for state and local forensic practitioners is, "What is our appropriate role in supporting the investigation of the terrorist incident?" The investigation of domestic terrorist acts is clearly a federal responsibility with the FBI designated as the lead agency. However, it is unrealistic to expect the FBI, the Department of Homeland Security, FEMA, Department of Defense, and others to be at the scene immediately, especially if multiple events occur. More likely, first responders will be made up of local police, fire, rescue, crime scene technicians, medical examiner personnel and forensic scientists. If several incidents occur simultaneously around the country, local first responders would be expected to handle the scene and the aftermath until federal assistance became available.

Not all the activities surrounding a terrorist attack are the responsibility of federal agencies such as the FBI. Some functions are clearly in the hands of the local authorities, such as the identification of mass civilian casualties. In the World Trade Center attacks, the New York City Office of the Chief Medical Examiner had the job of identifying the victims. Although other public and private resources will provide important assistance, the local medical examiner's office or the coroner has the primary responsibly to identify the dead. The problem is that few if any plans to deal with terrorist events consider a role for local and state forensic science resources.

Terrorism is one of many issues that forensic science practitioners and administrators must consider in the years to come; all of these issues can be viewed as part of a greater issue of a lack of planning. Stated simply, there is a critical need to develop a national forensic science strategy. Stakeholders who are part of the forensic science delivery system and users of forensic science services need to be brought together to consider all issues thoughtfully. Some are focused solely on forensic DNA testing, but the issues are much greater.

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The federal government recently called for the creation of a National Forensic Science Commission to study rapidly evolving advances in all areas of the forensic sciences and to make recommendations to maximize the use of the forensic sciences in the criminal justice system.[1] Such a commission could study the following areas, among others:

- **What is the value of forensic science applied to the criminal justice system?** There are currently no quantitative measures (other than anecdotal reports) to demonstrate the worth of investing in forensic science. If quantitative information can be developed to show that a small investment in forensic science results in significant value added to the overall effort of police and prosecutors, funding for forensic science should be easier to achieve. Similarly, no information is available to demonstrate the social value of forensic science to crime victims and their families. It would not be surprising to find that victims and their families are strongly supportive of public forensic science. These advocates could be marshaled as a force to secure more needed resources for forensic sciences. One only needs to consider the popularity of TV shows like CSI and a host of reality-based shows as an indicator of the public's interest in and potential support for forensic science.
- **How will future forensic science staffing needs be met?** It will be necessary to fill potentially thousands of forensic science positions due to retirements and a projected demand for more services. During the 1970s, Law Enforcement Assistance Administration (LEAA) funding resulted in the growth of forensic science labs and staffs around the U.S. Those persons hired at that time are now at the ends of their careers. In addition, the demand for DNA testing is likely to press the need for more forensic scientists in the future. As many as 10,000 new practitioners have been suggested in the next 5 to 10 years. How are we to educate, recruit and train this large number of new personnel? In addition, labs are looking for more forensic scientists at the M.S. and Ph.D. levels. For universities to run graduate level programs in the sciences, research dollars must be made available. However, the amount of research and development funds available to support forensic science at the National Institute of Justice is small and all but nonexistent from the National Science Foundation, and other funding sources.
- **Science and law issues should be considered.** Case law (*Daubert*[2] etc.) and the Federal Rules of Evidence (rule 702[3]) are being used by defense attorneys in criminal cases in an attempt to challenge the reliability of "pattern evidence," i.e., fingerprints, handwriting, footwear evidence, bite marks, etc. Courts are allowing these challenges because of changes in their views of science. Prior to *Daubert*, in order to be admissible, scientific evidence had to meet the *Frye* general acceptance standard. With changes in case law and the Federal Rules of Evidence, some defense attorneys have seized on the reliability issue to try to exclude certain classes of evidence. Although these attacks have generally been unsuccessful, it is reasonable

[1] March 11, 2003, U.S. Department of Justice Fact Sheet, The President's Initiative to Advance Justice through DNA Technology.
[2] *Daubert v. Merrell Dow Pharmaceuticals*, 113 S. Ct. 2786 (1993).
[3] "If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, **(2) the testimony is the product of reliable principles and methods**, and (3) the witness has applied the principles and methods reliably to the facts of the case."

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to expect the challenges to continue. The National Academies are considering a study of fingerprints, which if funded, may answer the reliability challenge much in the same way that DNA was deemed reliable after two National Research Council Reports.

- **What do public forensic science laboratories need?** An assessment of the needs of public forensic science institutions is necessary to help provide adequate resources to assist crime labs and medical examiner offices in providing quality and timely forensic science services to the criminal justice system. For example, can standards for the number of forensic scientists per 100,000 police officers be developed? Can standards for evidence turn-around times be established? What are reasonable amounts of continuing education training to require of forensic scientists? What is the federal government's role in developing solutions to these concerns?
- **What is the role of public forensic science labs at the state and federal level in the event of a terrorist attack?** As stated earlier, roles for state and local forensic science laboratories in the event of terrorist act have yet to be defined. Once a role is defined, will state and local forensic labs be ready to deliver the necessary services? The appropriate stakeholders must be brought together to consider this challenge.
- **Is collaboration between state and local forensic science and federal forensic science laboratories sufficient?** Federal forensic science labs play a vital role in the administration of justice and provide important support to state and local forensic science laboratories. However, a greater degree of collaboration between federal and state/local forensic science labs is desirable. Interaction between local and federal practitioners and lab administrators is important to allow all points of view to be considered and to make the best use of public tax monies.

The establishment of a national forensic science commission would have the desired effect of considering these and other critical issues with the desired outcome to develop well-considered public policy along with adequate funding. The justice system and the public at large are the beneficiaries of such a program.

Forensic science is more than just applied science. During the O. J. Simpson trial, colleagues called to tell me that the Simpson defense team, in order to raise questions about the crime scene procedures, was using an earlier edition of this textbook. I learned a powerful lesson from this case: *there is much more to crime scene investigation than simply proper police investigative techniques and forensic scientific and technical skill.* Appearance and perception as well as the ability to communicate effectively to a jury are equally important. "*It's not only important to be sharp; you have to look sharp, as well!*" That advice was given by an FBI instructor at a crime scene class I attended many years ago. To put it another way, appearances and perception are every bit as important as knowledge, skills, and ability, at least in the eyes of the jury and the public.

It would be naive for anyone planning a career in police work, forensic identification, or forensic science to underestimate the importance of the role of the expert witness in the courtroom. An investigator with the cleverness of Sherlock Holmes or a forensic scientist with the wisdom and understanding of Albert Einstein would be ineffective in a criminal investigation if he or she were unable to convince a jury made up of lay people. Verbal communication skills are every bit as important as technical expertise in being a successful expert witness.

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Professional ethics are also crucial. At one time, it would have been extraordinary to discuss integrity and ethics in a textbook on crime scene investigation. First, I apologize to the vast majority of practitioners who do not require any reminder. These professionals know that there is only one way to conduct their professional (and, hopefully, personal) lives — with honesty and integrity.

However, in a small number of instances, ethical failings among practitioners make restating some fundamental principles necessary. Criminal justice practitioners should know how to behave and what actions are right and honorable. For whatever reasons, notions of ethics, duty, and honor are ideals that have been forgotten by some. A discussion on the subject is in order because forensic practitioners and police investigators occasionally forget their public duty. In addition, those new to the profession must be told what their role in the criminal justice system is in clear, unmistakable terms.

A colleague once explained ethical conduct by using a simple statement: There is no way to make a wrong thing right! In a forensic context several examples of dishonorable conduct come to mind. The following situations, unfortunately, refer to actual incidents:

- Planting evidence at a crime scene to point to a defendant
- Collecting evidence without a warrant by claiming exigent circumstances
- Falsifying laboratory examinations to enhance the prosecution's case
- Ignoring evidence at a crime scene that might exonerate a suspect or be a mitigating factor
- Reporting on forensic tests not actually done out of a misguided belief that the tests are unnecessary
- Fabricating scientific opinions based on invalid interpretations of tests or evidence to assist the prosecution
- Examining physical evidence when not qualified to do so
- Extending expertise beyond one's knowledge
- Using unproved methodologies
- Overstating an expert opinion by using "terms of art" unfamiliar to juries
- Failing to report a colleague, superior, or subordinate who engages in any of the previously listed activities to the proper authorities

This list of wrongdoings can be categorized in several ways. Some failings are actually criminal in nature; they are felonies that could result in prison terms for the perpetrator. Others represent negligent conduct and could result in civil litigation against the expert, a superior, or the agency. Yet another class of failings constitutes unethical conduct that could result in censure, suspension, or expulsion from professional organizations. Occasionally, situations arise that contain an element of ambiguity. How might one determine the best course of action? Although the answer may not be clear in every case, one method is to ask the following questions:

- Would I be proud to tell my children or my parents what I did?
- How would my actions look on the front page of the morning newspaper?

If it remains uncertain whether actions are inappropriate or improper, seek the advice of a trusted professional colleague. Every forensic discipline has members who serve as pillars of the profession; seek out those persons and ask for guidance.

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Those of us who work for public agencies and who investigate criminal acts carry a difficult burden. The consequences of our conduct are considerable. Defendants convicted of capital crimes may face the death penalty or long years of confinement, in part from the physical evidence we collect and about which we provide expert testimony. It is troubling to think that those responsible for committing a criminal act may be set free because of actions committed or omitted by a forensic investigator. Indeed, few professions carry this amount of responsibility or hold such public trust as do forensic scientists and crime scene investigators.

Earlier, I mentioned the Simpson case. The criminal justice system and forensic science were also on trial. Many condemned the trial as a media circus because of the television courtroom coverage. Some believe that Mr. Simpson should have been convicted of the murders while others proclaimed that justice was done. In fact, the jury listened to the evidence and made its decision: The People failed to prove their case beyond a reasonable doubt to the jury's satisfaction.

Mr. Simpson's defense team used an earlier edition of this book to argue how physical evidence should have been handled and the proper techniques for conducting a crime scene investigation when they cross-examined the prosecution criminalists. There are few immutable rules in crime scene investigations. A notion I try to stress in this book is that a set of guidelines based on common sense can be applied to most crime scenes; however, guidelines cannot always be followed. Any experienced crime scene investigator knows that packaging wet, bloody evidence in plastic should be avoided. Wet biological evidence packaged in this manner will deteriorate much more quickly than air-dried evidence. Faced with blood-soaked clothing or bedding, however, separate packaging in a clean plastic trash bag for immediate transportation to the forensic science laboratory is an appropriate way to handle such items if there is no way to dry the items at the scene. Situations differ and it is important to be flexible.

As humans, we are subject to mistakes. It is impossible to handle every investigation without making some mistakes. At best, we can try to make as few errors as possible and to learn from past errors. Some people have a compelling urge to be "Monday-morning quarterbacks." Many of us would be wealthy indeed if we could receive a dollar for each time we have said, "If only I had collected that item of evidence," or "I should have done thus and so, a different way," or "Why didn't I think of that at the time; it seems so obvious now." The adage that "hindsight is always 20–20" is a fact of life with which we must live.

The Simpson case shifted to a degree the focus of forensic science from the laboratory to the crime scene. The crime scene investigation process now takes on a more important role than before. Defense attorneys have learned that if they are able to show that the initial handling of the physical evidence at the crime scene was faulty, then the evidence can be kept out of the trial, or at least tarnished in the eyes of the jury.

Training and continuing education for uniformed officers, detectives, crime scene investigators, and forensic scientists, especially in the proper collection and preservation of physical evidence at crime scenes, is extremely important. Training in the technical areas and in how to be a better expert witness needs to be stressed.

Written evidence-gathering procedures must also be reevaluated and, if necessary, rewritten. All law enforcement personnel involved in the investigation must follow their agency's policies and physical evidence procedures. The reasons for this are evident. Defense attorneys will attempt to show the written policies and procedures were not followed or, if policies and procedures do not exist, that the practices employed were not

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generally acceptable or personnel lacked appropriate training. The results are the same: even if forensic tests point to the defendant, improper or inadequate evidence collection and preservation techniques will render the evidence inadmissible or its value will be diminished.

A better-informed defense bar will also raise questions about the quality of forensic science laboratories and their forensic practitioners. One way to evaluate a laboratory's quality is to inquire if it is accredited. In the U.S. and several foreign countries, that means American Society of Crime Laboratory Directors — Laboratory Accreditation Board (or ASCLD/LAB)[4] accreditation. Other programs have been developed that follow the ISO 17025 standards[5] as well.

In fact, with the number of public forensic laboratories that have already become accredited, it is only a matter of time before accreditation will be a *de facto* requirement for evidence admissibility. No one is likely to undergo surgery in a nonaccredited hospital; similarly, courts, prosecuting and defense attorneys, the police, and the public should demand that their laboratories meet basic forensic science laboratory accreditation standards such as those articulated in ASCLD/LAB accreditation criteria.

Just as a forensic science user should expect a laboratory to be accredited, a similar question may be asked of the forensic science practitioner: is he or she board certified? There are a number of professional accrediting bodies. In the criminalistics arena, it is the American Board of Criminalistics.[5] The International Association for Identification[6] offers an exemplary certification program in fingerprint identification and crime scene investigation. There are also other forensic science and medical certifying bodies in areas such as questioned documents, toxicology, dentistry, pathology, anthropology, and psychiatry that help to identify competent practitioners.

Certification of forensic scientists: 1) measures quality, 2) enhances credibility, 3) introduces a degree of peer standardization, and 4) enhances consumer confidence. However, not all certifying programs are to be trusted. Persons considering a board certifying program are encouraged to evaluate them critically. A program that does little more than require the payment of a fee should raise questions. *Caveat emptor!*

Continuing education and attendance at professional association seminars and workshops are essential to professional competency and professional development. To demonstrate this point, ask, "Would I consider going to a physician, dentist, accountant, lawyer, or other professional who does not periodically attend continuing education classes to keep up his or her professional competency?" Funds for professional development should be considered a priority in all law enforcement organizations that operate forensic science laboratories and fingerprint identification laboratories.[7]

Just as continuing education and training are important, so is ongoing competency or proficiency testing for forensic scientists and forensic science laboratories. There are a variety of proficiency testing modalities that demonstrate mastery of technical procedures. Proficiency testing need not be double blind. Proficiency testing can be: blind, declared, reanalysis, interlaboratory, or "round robin." Proficiency test results are public records and

[4] http://www.ascld-lab.org/
[5] http://www.criminalistics.com/abc/A.php
[6] http://www.theiai.org/certifications/
[7] An agency should plan on budgeting about $1,500 per examiner per year for continuing education and training if it hopes to operate a quality forensic science or identification laboratory (NIJ Technical Working Group on Education and Training in Forensic Science).

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can be subpoenaed to demonstrate how well laboratories and practitioners perform in such tests.

Forensic science funding needs are often ignored until some horrific revelation brings them notice. Often inadequate funding goes along with inadequate oversight from the local criminal justice establishment. Quality and timely work have a price tag and inadequate funding has consequences. Parent organizations must remember to fund staff and support operations in addition to line units. Failure to provide adequate funding to ensure quality work and timely lab service is unconscionable. The damage done when failures in the forensic science delivery system occur can be appalling. The citizens of a democracy have a right to expect that justice be administered fairly and impartially. Should that expectation be any different for an essential element of public safety — forensic science?

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1 Introduction

Webster's Dictionary defines evidence as something legally submitted to a competent tribunal as a means of ascertaining the truth of any alleged matter of fact under investigation before it. Police investigators deal with evidence on a daily basis. Their ability to recognize, collect, and use evidence in criminal investigations determines to a large degree their success as investigators.

Evidence can be divided into two broad types: (1) testimonial evidence and (2) real, or physical, evidence. Testimonial evidence is evidence given in the form of statements made under oath, usually in response to questioning. Physical evidence is any type of evidence with an objective existence, that is, anything with size, shape, and dimension.

Physical evidence can take any form. It can be as large as a house or as small as a fiber. It can be as fleeting as an odor or as obvious as the scene of an explosion. In fact, the variety of physical evidence that may be encountered in an investigation is infinite.

What is the value of physical evidence and why should police investigators concern themselves with an understanding of the uses and ways to collect physical evidence?

Physical evidence can prove a crime has been committed or establish key elements of a crime.

Case. Proof of rape requires showing nonconsensual sexual intercourse. In an alleged rape case, the victim's torn clothing and bruises were sufficient to prove nonconsent.

Case. Arson investigators dispatched to the scene of a suspicious fire collected some burned carpeting. Later analysis proved that gasoline was present in the carpet, proving that the fire was intentionally started and, therefore, arson.

Physical evidence can place the suspect in contact with the victim or with the crime scene.

Case. A suspect was apprehended shortly after an alleged rape in the victim's home. Cat hair was found on the lower portion of the suspect's trousers, which the suspect was at a loss to explain. The victim owned two cats.

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Figure 1.1 In order for a defendant to be charged with possession of a controlled substance, the forensic science laboratory must establish that the seized evidence is listed in the code. Labels on pharmaceuticals sometimes describe one drug when in fact the container holds another. In this case, some of the steroids were tested and found to be different steroids from those listed as the contents. *(Los Angeles County Sheriff's Department.)*

Physical evidence can establish the identity of persons associated with the crime.

Case. Every safe burglar knows not to leave fingerprints at the crime scene, so it was not surprising to find at the scene latex surgical gloves that were used on the safe. The identity of the burglar was established by developing fingerprints inside the rubber gloves.

Case. DNA typing proved that a lone defendant was responsible for a series of rape cases in a major metropolitan area.

Physical evidence can exonerate the innocent.

Case. An 8- and 9-year-old brother and sister accused an elderly neighbor of child molestation. They claimed that the man gave each of them pills that made them feel drowsy and then he molested them. The investigator had a physician examine the children and blood and urine specimens were collected for a toxicology screen. The analyses of the blood and urine specimens were negative. When presented with this information, the children confessed that they had fabricated the entire story because they disliked their neighbor.

Physical evidence can corroborate the victim's testimony.

Case. A motorist picked up a female hitchhiker. She claimed that he pulled a knife and attempted to rape her. During the struggle, the woman's thumb was cut before she managed to escape. She related her story to the police and the suspect was eventually arrested. During the interrogation, the suspect steadfastly proclaimed his innocence. The investigator noted a small quantity of dried blood on the suspect's left jacket lapel. He claimed the blood came from a shaving mishap. The investigator submitted the jacket along with blood samples from the suspect and the victim to the crime laboratory. The results indicated that the blood on the jacket could not have come from the suspect, but came from the victim. The physical evidence was instrumental in obtaining a conviction for attempted rape.

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Figure 1.2 Example of a physical match. A comb (A) with three missing teeth was found in the suspect's possession. Two plastic teeth (B) found at the crime scene were fitted to the comb (C). The evidence placed the victim at a burglary. *(Los Angeles County Sheriff's Department.)*

A suspect confronted with physical evidence may make admissions or even confess.

Case. Cattle rustling still occurs from time to time. Blood found on a suspect's shirt was tested and determined to be bovine, that is, from a cow. The suspect, who first claimed the blood was his own, made a full admission when confronted by the evidence.

Physical evidence may be more reliable than eyewitnesses to crimes.

Psychological experiments have shown that observations made by test subjects in simulated violent crimes are inaccurate over a period of time after the event.

Study. Volunteers in a psychological test were witnesses to staged assaults. At the conclusion of the mock crimes, they were asked to detail their observations in writing. Over a period of several months, they repeatedly were asked to write down what they had observed.

The study showed that people fill in gaps to events not observed. If a portion of an event was not seen or did not make sense, the subjects made up scenarios that seemed reasonable to the episode. This behavior occurred subconsciously; subjects were not aware that it was taking place. They simply reported what they believed they had seen.

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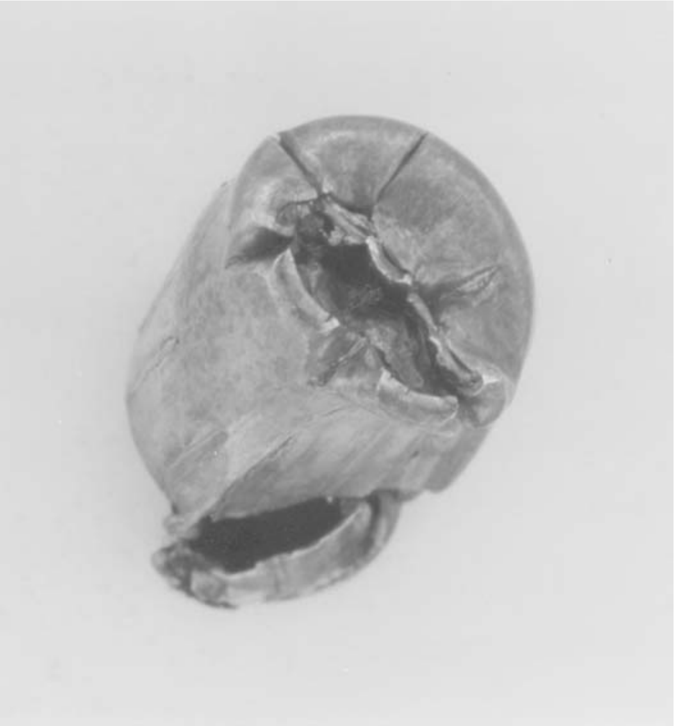

Figure 1.3 (A color version of this figure follows page 256.) The order of clothing fragments caught in the hollow-point round fired by a deputy sheriff helped to reconstruct the sequence of events in an officer-involved shooting. An innocent bystander and an armed robber were killed by the shot and it was up to the lab to determine who was struck first. The order of the fragments of clothing proved that the bullet first hit the robber and then the bystander. *(Los Angeles County Sheriff's Department.)*

Court decisions have made physical evidence more important.

The U.S. Supreme Court, in a number of decisions such as *Miranda*, has limited the authority of the police to rely on statements and confessions made by defendants. These landmark cases have, in effect, shifted the attention in proving cases to physical evidence.

Juries in criminal cases expect physical evidence.

Two unrelated factors have biased the public's notion of the role of physical evidence in criminal cases. Jurors expect physical evidence in a trial; after all, that is the way it is on television shows such as *CSI: Crime Scene Investigation*, Court TV and other programs. Science and technology are perceived by the public to be unbiased and not subject to manipulation. If scientific testing is used to evaluate and characterize physical evidence, the public is more inclined to believe that the police investigation was properly conducted.

Negative evidence — the absence of physical evidence may provide useful information and even stop defense arguments at the time of trial.

Case. In an insurance fraud, the victim claimed his home was burglarized. No evidence of forced entry could be found and eventually the fraud was discovered.

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Figure 1.4 The victim in this case was raped and strangled in her home in a suburb of Beijing. The criminal tried to disguise the crime scene by tying a lamp cord from a desk lamp around the victim's neck and making the death appear to be a suicide. A latent fingerprint was discovered on the base of the lamp using super glue. The case was solved when the latent print was matched to a neighborhood youth who had claimed never to have been in the victim's house. *(Institute of Forensic Science, Beijing, China.)*

Identification and Individualization of Physical Evidence

Some investigators may think that every item of physical evidence can be directly associated to a specific person, place, or thing and believe that it is possible for a single strand of hair or a fiber to be linked to a unique source. This is not generally the case. Although some types of physical evidence may come from one and only one source, most physical evidence may only be associated with a class or group. Only a few kinds of physical evidence can be individualized. Individualization means that an item of evidence comes from a unique source. It can be shown to be directly associated with a specific individual source. A broken piece of plastic physically fitted to reconstruct an item is an example of individualization. Other types of evidence including fingerprints, tool marks and fired bullets are examples of evidence that may be associated with a unique source (Figure 1.5).

The majority of physical evidence found at crime scenes can only be identified. Identification means that the items share a common source. The items can be classified or placed into groups with all other items having the same properties.

The difference between individualization and identification can be a subtle one. Consider the following example: a blue-colored cotton fiber is found at the scene of a burglary. A suspect wearing a torn blue cotton shirt is apprehended. All the tests conducted at the crime laboratory on the evidence fiber and exemplar fibers from the shirt show them to

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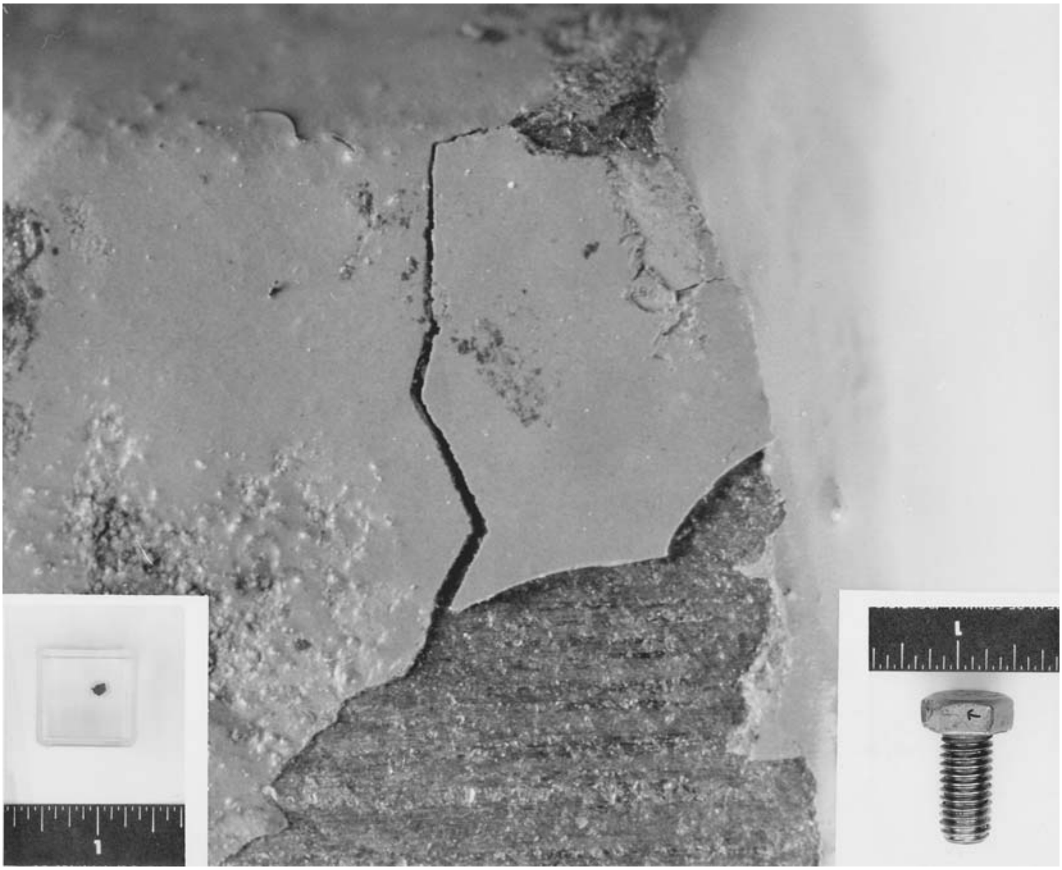

Figure 1.5 Physical matches are another example of individual characteristics. The tiny paint chip in the evidence container on the left inset was removed from the suspect's wrench and a physical match was made to an area on the bolt (bottom right inset) from a safe. The photograph shows a close-up of the physical match. *(Illinois State Police.)*

be identical. Can it be concluded that the blue cotton fiber found at the scene definitely came from the torn blue cotton shirt worn by the suspect? (See Figure 1.6.)

No! The best that can be stated from this information is that the fiber *could have* come from the shirt in question or any other one manufactured with similar blue cotton fibers. The item has been identified as a blue cotton fiber and can be placed into a class of all other similar blue cotton fibers. No matter how much testing is done on that evidence, the conclusion will always be the same.

Contrast the fiber with a fingerprint. The fingerprint may be identified. It can be placed into a group, e.g., a whorl or loop. In addition, fingerprint evidence can go well beyond identification; fingerprints can be shown to be unique. An examination can show that the latent print comes from only one person and no other. The print has been individualized.

Most physical evidence cannot definitely connect a suspect to a crime as fingerprint evidence can. This should not diminish the usefulness of that evidence. Physical evidence that is identified can corroborate testimony, place a subject at a scene, and be useful in a variety of ways as an interrogation tool (Figure 1.7).

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Figure 1.6 Class characteristics place an item of evidence in a specific class or group. The upper two strap segments in the photograph were found in a murder suspect's van. The lower strap is of similar manufacture, design, and material content. It was from a similarly designed and manufactured swimsuit reported to have been worn by the victim. This is an example of class characteristics. *(Los Angeles County Sheriff's Department.)*

Case

During a robbery of a Ventura cocktail lounge, a lone gunman tied the manager hand and foot with lengths of white plastic clothesline. Later, another robbery occurred at a cocktail lounge approximately 20 miles north of Ventura, during which the manager was bound with white plastic clothesline in the same fashion. This time, however, the victim was shot and killed by a single .45-caliber bullet fired into the back of his head.

An intensive investigation led to a suspect, a middle-aged part-time cook who resided in Van Nuys, immediately northwest of Los Angeles. A search of his car led to the discovery of a 24-foot length of white plastic clothesline in the car trunk and two lengths of clothesline, each about 40 inches long, under the driver's seat.

Laboratory examinations conducted by the Ventura County (California) Sheriff's Department crime laboratory disclosed that the sections of clothesline from the three sources all bore the same class characteristics, including the physical and chemical composition of the plastic components. The components consisted of 121 interior filaments of nine different plastic types and one metallic filament, all

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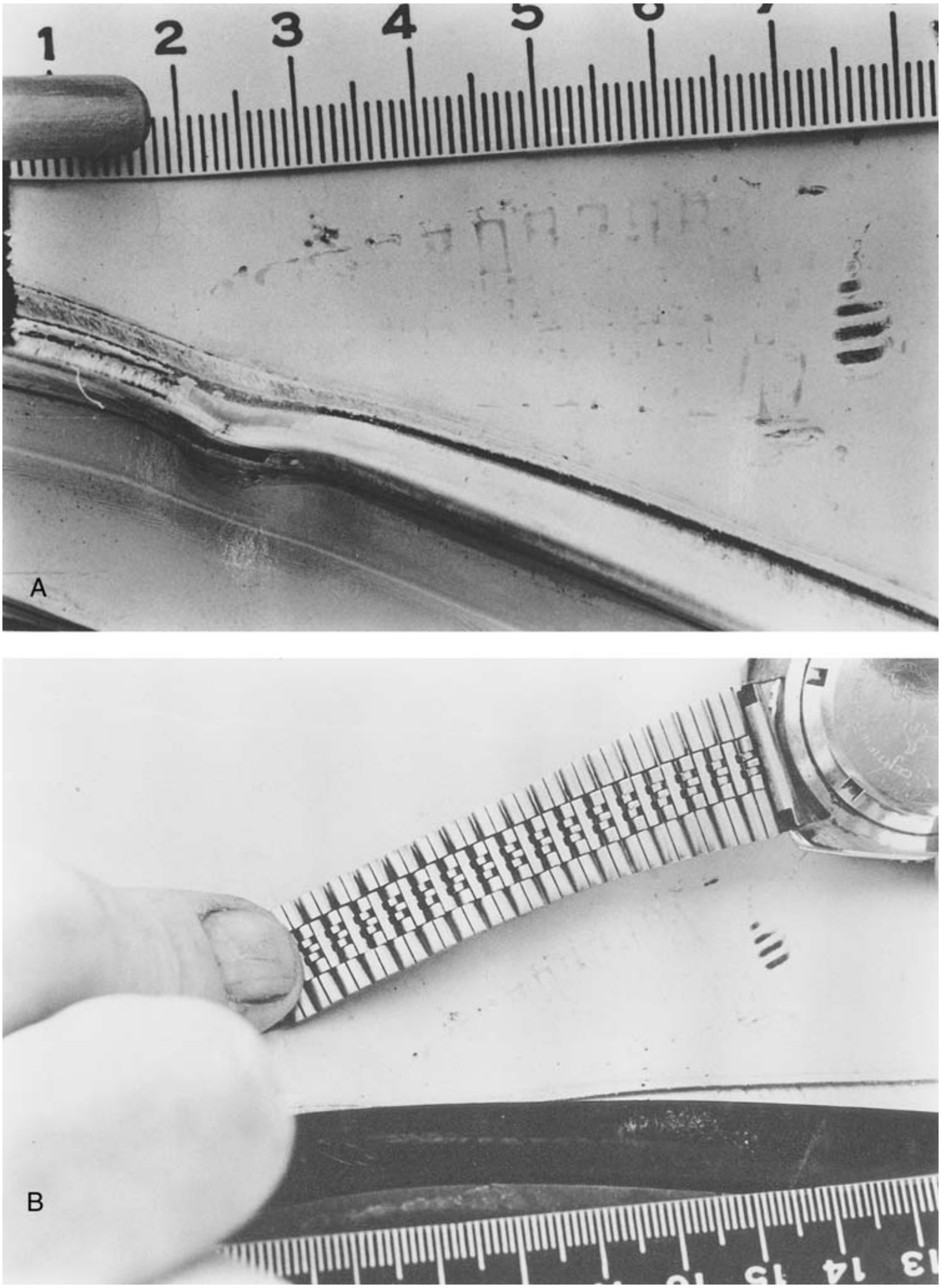

Figure 1.7 These items provide an unusual example of class characteristics. The body of a hit-and-run victim was found next to a major highway. A suspect vehicle was located with an unusual impression (A) that matched the pedestrian's wristwatch band (B). *(Division of Identification and Forensic Science, Israel National Police.)*

contained in a white plastic cover. The outer covers or sheaths were approximately one-quarter inch in diameter. Examination of the interior portion of the sheaths showed that the perimeter filaments left their impressions permanently in the interior of the sheaths as a result of the manufacturing process. In this process the

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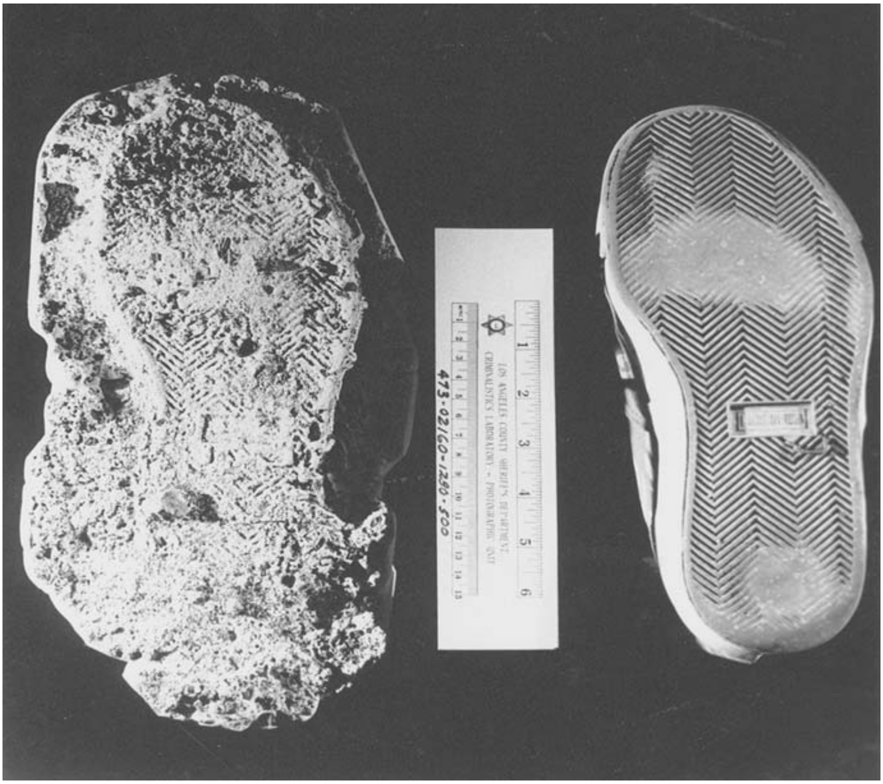

Figure 1.8 Sometimes class characteristics may be unusual enough to permit the inference that an item of evidence came from a single source. This illustration shows a plaster cast (left) taken from a burglary scene and the suspect's shoe (right). (The photographic negative was flipped in order to show the cast in reverse orientation so that the two items can be more easily examined.) The tread on the sole and that on the plaster cast have the same design and similar wear patterns. The staple in the sole, also found in the cast, is convincing evidence that this shoe made the impression. *(Los Angeles County Sheriff's Department.)*

filaments constituting the core are pulled through white PVC melt and extruded to produce the white outer cover (Figure 1.9).

Experiments showed that successive cross-section cuts along a single clothesline section, one-quarter inch apart, resulted in noticeable differences because the filaments vary in position from point to point along the clothesline. By virtue of this strong individual characteristic, these filament impressions constituted the strongest single feature of identification. As a result, the Ventura robbery was conclusively tied to the suspect. On the other hand, the robbery/murder case was not connected conclusively through the clotheslines. No matching ends were present to tie this case with the first robbery or the car.

Measurements of all the clothesline sections, collectively, indicated that less than one complete clothesline was present. A shortage of about 10 feet existed. For all that is known, a portion or parts of it may be lying on a police property room shelf somewhere perhaps to link another crime. In any event, the accused person was convicted of robbery and murder, based on the plastic clothesline and other physical evidence.

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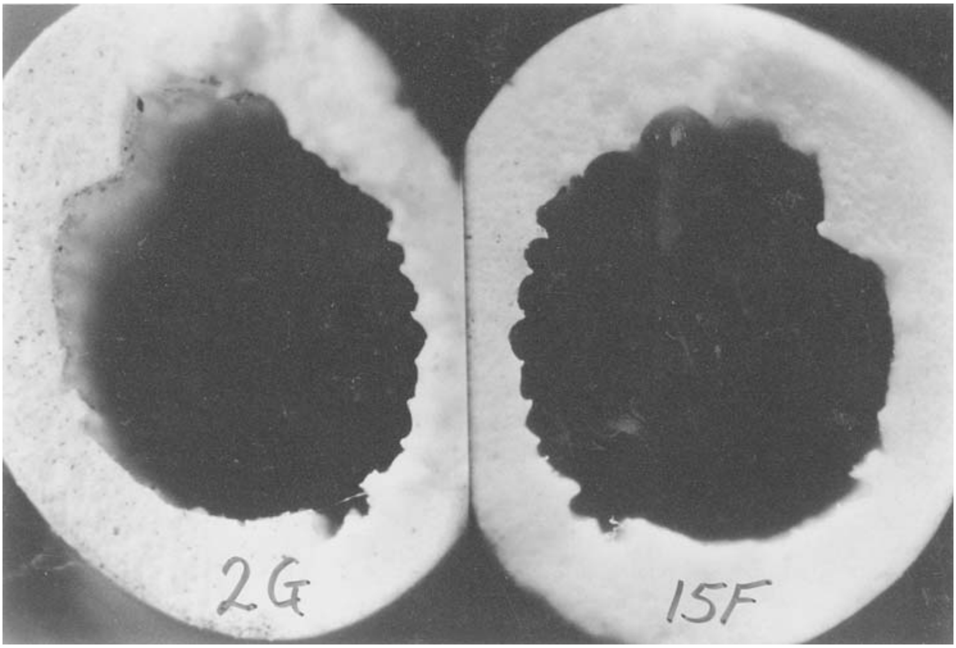

Figure 1.9 Cross-sections of the clothesline, showing similarities. *(Ventura County Sheriff's Department, Ventura, California.)*

Collection and Preservation of Physical Evidence

The major theme of this text concerns the proper handling of physical evidence. Two of the main areas that must be considered in any discussion of the proper techniques of collection and preservation of physical evidence are the legal and scientific issues concerning collection and preservation of physical evidence.

Although laws regarding physical evidence vary from state to state, they have many similarities. Before any evidence is seized, the need for a search warrant or court order should be considered. Case law is constantly changing, so investigators should keep abreast of the latest developments. Depending on circumstances, court orders may be required for searching the crime scene and collecting evidence, such as blood samples, hair specimens, medical tests, and teeth impressions, from a suspect. The prosecutor's office should be consulted if there is any doubt.

Failure to secure a search warrant may result in severe legal sanctions by the court. In some cases, the physical evidence seized at a crime scene may be inadmissible in court for lack of a warrant. In fact, a legal doctrine called *fruit of the poison tree* provides that any subsequent information derived from illegally seized physical evidence is inadmissible in court and cannot be used.

Stated simply: if unsure of the situation, consult with the prosecutor's office. Mistakes in this area can be costly and cases have been lost for lack of search warrants or court orders to seize evidence.

The concept of a "chain of custody" or "chain of evidence" is important to understand. A court will require proof that evidence collected during an investigation and the evidence ultimately submitted to the court are one and the same. To prove that the integrity of the

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physical evidence has been maintained, a chain of custody must be demonstrated. This *chain* shows who had contact with the evidence, at what time, under what circumstances, and what changes, if any, were made to the evidence.

Typically, evidence is put into a container with a label or tagged. Identifying information pertaining to the case is written on the container or tag as well as in reports and logs to establish the chain. Police department policy may dictate which information is required, but usually the following types of information are needed to establish the chain of custody:

- Name or initials of the individual collecting the evidence and each person subsequently having custody of it
- Dates the item was collected and transferred
- Agency, case number, and type of crime
- Victim's or suspect's name
- Brief description of the item

This information serves to prove the chain of custody to the court and assists in admitting the items into evidence.

Storage of physical evidence has legal implications. Evidence must be held in a secured area prior to transportation to court. Evidence reasonably assumed to have been tampered with by unauthorized persons because it was kept in an unsecured area may be inadmissible in court. Evidence should be maintained in a specific secured area, with limited access by authorized persons.

Several scientific issues of proper collection and preservation of evidence require discussion.

Sufficient material should be collected. Judging the amount of specimen to gather is largely a matter of experience. As a general rule, however, as much material as is reasonably possible to collect should be taken. Generally, it is impractical and sometimes impossible to return to a crime scene at a later time to collect more material if more physical evidence should be needed. As a general rule, more is better than less.

Many forensic science laboratory examinations compare a known specimen with a questioned specimen. Known or control exemplars are needed for these comparative laboratory analyses. For example, if a bloodstained shirt is submitted to a crime laboratory, the DNA typing results must be compared with something in order to provide useful information. A known biological sample from the victim and suspect is needed. (Some labs will use a swabbing from a subject's mouth while others may use a blood specimen.) Similarly, if an automobile paint specimen is submitted for laboratory analysis, a known sample of paint from the questioned vehicle must be submitted for comparison.

Blank samples may be important. Consider an arson investigation. An issue may be raised that heat from a fire may cause wood or carpeting to give off products that might be confused with combustible material. Unburned samples of wood or carpet can be collected for testing to clarify this contention. Blank samples are used to verify that the uncontaminated samples do not interfere with the analysis.

Physical evidence should be handled as little as possible. Too much handling may obliterate fingerprints, dislodge minute trace evidence such as hair, fibers, and debris, break apart brittle evidence, or contaminate evidence. Forceps, latex gloves, and special containers may be necessary for handling physical evidence.

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Figure 1.10 In this example of individualization, a receipt for payment of a monthly bus ticket (A) purchased by a murder victim was compared with a ticket found in the suspect's home (B). The two pieces were originally part of the same ticket (C). *(Institute of Forensic Science, Beijing, China.)*

Crime scene investigators should have an assortment of envelopes, containers, and packaging on hand to properly collect and preserve physical evidence. Plastic bags are generally avoided. This is particularly true when preserving biological evidence such as bloodstained articles because plastic bags accelerate deterioration. However, if it is necessary to transport blood-soaked articles that cannot be air-dried at the crime scene directly to the laboratory for processing, plastic containers may be used in limited circumstances and for short periods.

Airtight containers are desirable for volatile materials such as gasoline. Clean glass jars with lined screw-cap lids or clean metal paint cans with wide-mouth openings make excellent containers for arson evidence. Burned debris that is to be checked for combustible materials should never be packaged in plastic bags or plastic jars because volatile evidence will pass through most plastics.

It is good practice to double-wrap very small items such as hair, fibers, or glass fragments. These items should first be folded up in a sheet of paper and then placed in an envelope. Careful packaging of minute items of evidence will ensure that they are not lost.

Contamination is a concern for proper preservation of evidence. Items of evidence should be packaged separately in individual containers. Each piece of evidence should be completely segregated from other evidence.

Case. A burglary suspect was apprehended near a residential tract; he had broken into a house through the rear door. The arresting officer observed splinters, paint, and other building material on the suspect's jacket. Samples from around the point of entry were

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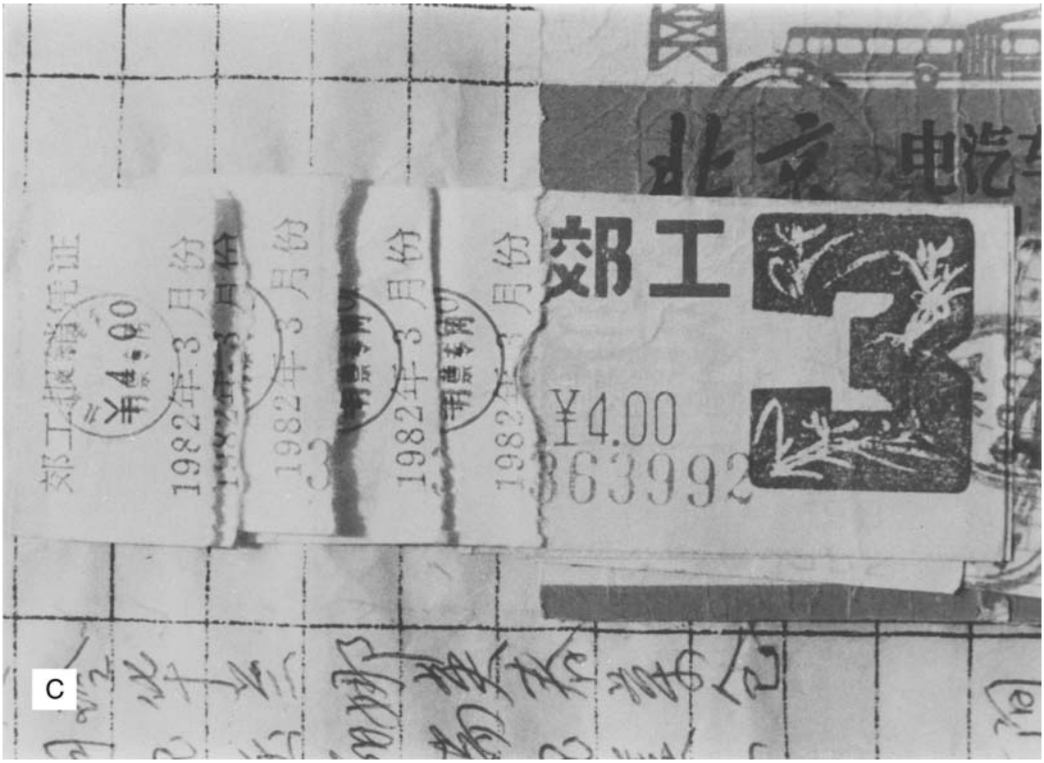

Figure 1.10 (continued)

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collected for comparison and submitted with the jacket to the crime laboratory. All the evidence was packaged together in a paper bag. When it arrived at the crime laboratory, it was not possible to tell whether the debris on the jacket was from the crime scene or from the known samples collected by the investigator and placed into the bag with the suspect's clothing.

Microscopic or trace evidence presents unique collection problems. A number of techniques are available to collect this type of evidence. Vacuum cleaners specially equipped with traps can be used to collect trace evidence such as hairs, fibers, glass fragments, and debris. Evidence collection vacuums are available commercially, or normal household vacuum cleaners can be modified to collect trace evidence. However, the technique indiscriminately collects relevant trace evidence as well as large amounts of debris with no relationship to the crime.

An alternative method for collecting trace evidence consists of simply shaking or sweeping an item such as clothing and allowing the trace material to fall onto a clean sheet of paper. Others prefer to use cellophane tape. A 4-inch length of tape is pressed onto suspected areas and then placed, sticky side down, on a microscope slide.

Each of these techniques has advantages and disadvantages. Before one technique is chosen over another, it is strongly recommended that the crime laboratory used by the police agency be consulted because the lab may prefer different practices.

Specially trained personnel — forensic scientists, criminalists, forensic technicians, or identification technicians — examine physical evidence collected at crime scenes. These practitioners are unique because they must prepare reports and testify in court as expert witnesses. Because scientific principles relating to physical evidence are often beyond the knowledge of lay people, courts permit persons with specialized training and skills to appear in court to explain and interpret scientific evidence to juries. Expert witnesses can be used when the subject of the testimony is beyond the experience and knowledge of ordinary lay people and when the expert has sufficient skills, knowledge, or experience in his or her field to help the judge or jury determine the truth.

Those entrusted with the investigation of criminal activity carry a heavy burden. Although the ultimate solution of the crime is a primary goal, one cannot forget that all activity surrounding the investigation will be scrutinized at some later time. Actions taken during the investigative phase, e.g., interviews, collecting and preserving physical evidence, documenting the crime scene, etc., must be done in the proper legal fashion so that evidence can be admitted when the case goes to trial. Mistakes are often unforgiving; there are scores of examples where unintentional errors have been made that resulted in evidence being declared inadmissible by the courts. The best advice is to consider all the ramifications before taking action.

Important Considerations in Crime Scene Investigations

In addition to the "how-to" elements of crime scene investigation, several other issues need to be discussed. These represent a philosophical approach to the subject and should be considered an integral part of forensic science and forensic identification.

Forensic scientists, crime scene specialists, and latent fingerprint experts are the individuals whose jobs apply science and technology to the solution of criminal acts. They

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shoulder an important role in the criminal justice system. Their skill and knowledge in the criminal investigation may establish the innocence or guilt of a defendant. Professional ethics and integrity are essential to their effort.

Many forensic specialists work for law enforcement agencies that are responsible for the criminal investigation and/or the prosecution of cases. While some may argue that employment by police agencies offers the potential for bias, in fact, it is the integrity of the professional and the organization that is the deciding factor.

All forensic practitioners owe a duty to the truth. They may never be biased for or against a suspect in an investigation. The forensic practitioner's sole obligation is to serve the aims of justice. It makes no difference whether a defendant is ultimately found guilty of the crime or not. What is important is that the forensic practitioner conducted the investigation in a thorough, competent, unbiased manner.

Forensic practitioners have an obligation not to overstate or understate scientific findings. As experts in the criminal justice system, they are placed in positions of authority and responsibility. Because of their education, training, experience, and skills, their opinions on technical matters often carry considerable importance.

For forensic science practitioners to perform their function within the legal system properly, they must exercise independence and integrity. Stated simply, forensic scientists cannot be biased for or against an investigation in which they are involved. Their job is to champion their own expert opinions based on accepted, properly performed scientific inquiry. Forensic scientists who understand their role in the criminal justice arena help to protect individual rights and freedoms while ensuring that justice is delivered.

Like practitioners, managers of forensic science laboratories must be concerned about professional ethics. The American Society of Crime Laboratory Directors (ASCLD) adopted a code of professional practices, *Guidelines for Forensic Laboratory Management Practices.* They are included here as a definition of good laboratory management practices.

Guidelines for Forensic Laboratory Management Practices

Introduction

The American Society of Crime Laboratory Directors is a professional organization of managers and supervisors employed in forensic laboratories. We are the holders of a public trust because a portion of the vital affairs of other people has been placed into our hands by virtue of the role of our laboratories in the criminal justice system. The typical users of forensic laboratory services are not in a position to judge the quality of our work product or management for themselves. They must rely on the expertise of individual professional practitioners and the standard of practice maintained by the profession as a whole.

The purpose of this document is to provide guidelines for the conduct of managers and supervisors of forensic laboratories so as to safeguard the integrity and objectives of the profession. These are not immutable laws nor are they all inclusive. Instead, they represent general standards which each manager and supervisor should strive to meet. Laboratory managers must exercise individual judgment in complying with the general guidelines in this document. The guiding

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principle should be that the end does not justify the means; the means must always be in keeping with the law and with good scientific practice.

Responsibility to the Employer

Employers rarely have the ability to judge the quality and productivity of their forensic laboratory. Therefore, the employer relies upon the forensic manager to develop and maintain an efficient, high quality forensic laboratory.

Managerial Competence

Laboratory managers should display competence in direction of such activities as long range planning, management of change, group decision making, and sound fiscal practices. The role(s) and responsibilities of laboratory members must be clearly defined.

Integrity

Laboratory managers must be honest and truthful with their peers, supervisors and subordinates. They must also be trustworthy and honest when representing their laboratories to outside organizations.

Quality

Laboratory managers are responsible for implementing quality assurance procedures which effectively monitor and verify the quality of the work product of their laboratories.

Efficiency

Laboratory managers should ensure that laboratory services are provided in a manner which maximizes organizational efficiency and ensures an economical expenditure of resources and personnel.

Productivity

Laboratory managers should establish reasonable goals for the production of casework in a timely fashion. Highest priority should be given to cases which have a potentially productive outcome and which could, if successfully concluded, have an effective impact on the enforcement or adjudication process.

Meeting Organizational Expectations

Laboratory managers must implement and enforce the policies and rules of their employers and should establish internal procedures designed to meet the needs of their organizations.

Health and Safety

Laboratory managers are responsible for planning and maintaining systems that reasonably assure safety in the laboratory. Such systems should include mechanisms for input by members of the laboratory, maintenance of records of injuries and routine safety inspections.

Security

Laboratory managers are responsible for planning and maintaining the security of the laboratory. Security measures should include control of access both during and after normal business hours.

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Management Information Systems

Laboratory managers are responsible for developing management information systems. These systems should provide information that assists managers and the parent organization in decision making processes.

Responsibility to the Employee

Laboratory managers understand that the quality of the work generated by a laboratory is directly related to the performance of the staff. To that end the laboratory manager has important responsibilities to obtain the best performance from the laboratory's employees.

Qualifications

Laboratory managers must hire employees of sufficient academic qualifications or experience to provide them with the fundamental scientific principles for work in a forensic laboratory. The laboratory manager must be assured that employees are honest, forthright and ethical in their personal and professional life.

Training

Laboratory managers are obligated to provide training in the principles of forensic science. Training must include handling and preserving the integrity of physical evidence. Before casework is done, specific training within that functional area shall be provided. Laboratory managers must be assured that the employee fully understands the principles, applications and limitations of methods, procedures and equipment they use before beginning case work.

Maintaining Employees' Competency

Laboratory managers must monitor the skills of employees on a continuing basis through the use of proficiency testing, report review and evaluation of testimony.

Staff Development

Laboratory managers should foster the development of the staff for greater job responsibility by supporting internal and external training, providing sufficient library resources to permit employees to keep abreast of changing and emerging trends in forensic science, and encouraging them to do so.

Environment

Laboratory managers are obligated to provide a safe and functional work environment with adequate space to support all the work activities of the employee. Facilities must be adequate so that evidence under the laboratory's control is protected from contamination, tampering or theft.

Communication

Laboratory managers should take steps to ensure that the employees understand and support the objectives and values of the laboratory. Pathways of communication should exist within the organization so that the ideas of the employees are considered when policies and procedures of the laboratory are developed or revised. Communication should include staff meetings as well as written and oral dialogue.

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Supervision

Laboratory managers must provide staff with adequate supervisory review to ensure the quality of the work product. Supervisors must be held accountable for the performance of their staff and the enforcement of clear and enforceable organizational and ethical standards. Employees should be held to realistic performance goals which take into account reasonable workload standards. Supervisors should ensure that employees are not unduly pressured to perform substandard work through case load pressure or unnecessary outside influence. The laboratory should have in place a performance evaluation process.

Fiscal

Laboratory managers should strive to provide adequate budgetary support. Laboratory managers should provide employees with appropriate, safe, well-maintained and calibrated equipment to permit them to perform their job functions at maximum efficiency.

Responsibility to the Public

Laboratory managers hold a unique role in the balance of scientific principles, requirements of the criminal justice system and the effects on the lives of individuals. The decisions and judgments that are made in the laboratory must fairly represent all interests with which they have been entrusted. Users of forensic laboratory services must rely on the reputation of the laboratory, the abilities of its analysts and the standards of the profession.

Conflict of Interest

Laboratory managers and employees of forensic laboratories must avoid any activity, interest or association that interferes or appears to interfere with their independent exercise of professional judgment.

Response to Public Needs

Forensic laboratories should be responsive to public input and consider the impact of actions and case priorities on the public.

Professional Staffing

Forensic laboratories must hire and retain qualified personnel who have the integrity necessary to the practice of forensic science. Verification of academic, work experience and professional association credentials is essential.

Recommendations and References

Professional recommendations of laboratories and/or analysts should be given only when there is knowledge and an endorsement of the quality of the work and the competence of the laboratory/analyst. Referrals of clients to other professional colleagues carry a lesser degree of endorsement and are appropriate when a laboratory is unable to perform the work requested.

Legal Compliance

Laboratory managers shall establish operational procedures in order to meet constitutional and statutory requirements as well as principles of sound scientific practice.

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Fiscal Responsibility

Public laboratories should be managed to minimize waste and promote cost effectiveness. Strict inventory controls and equipment maintenance schedules should be followed.

Accountability

Laboratory managers must be accountable for decisions and actions. These decisions and actions should be supported by appropriate documentation and be open to legitimate scrutiny.

Disclosure and Discovery

Laboratory records must be open for reasonable access when legitimate requests are made by officers of the court. When release of information is authorized by management, all employees must avoid misrepresentations and/or obstructions.

Work Quality

A quality assurance program must be established. Laboratory managers and supervisors must accept responsibility for evidence integrity and security; validated, reliable methods; casework documentation and reporting; case review; testimony monitoring; and proficiency testing.

Responsibility to the Profession

Laboratory managers face the challenge of promoting professionalism through the objective assessment of individual ability and overall work quality in forensic sciences. Another challenge is dissemination of information in a profession where change is the norm.

Accreditation

The Laboratory Accreditation Board (ASCLD/LAB) provides managers with objective standards by which the quality of work produced in forensic laboratories can be judged. Participation in such a program is important to demonstrate to the public and to users of laboratory services the laboratory's concern for and commitment to quality.

Peer Certification

Laboratory managers should support peer certification programs which promote professionalism and provide objective standards that help judge the quality of an employee's work. Meaningful information on strengths and weaknesses of an individual, based on an impartial examination and other factors considered to be important by peers, will add to an employee's abilities and confidence. This results in a more complete professional.

Peer Organizations

Laboratory managers should participate in professional organizations. They should encourage employee participation in professional societies and technical working groups which promote the timely exchange of information among peers. These societies prove their worth to forensic science, benefiting both the employee and employer, through basic training as well as continuing education opportunities.

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Personal contacts with other agencies and laboratories with similar interests are also beneficial for professional growth.

Research

When resources permit, laboratory managers should support research in forensic laboratories. Research and thorough, systematic study of special problems are needed to help advance the frontiers of applied science. Interaction and cooperation with college and university faculty and students can be extremely beneficial to forensic science. These researchers also gain satisfaction knowing their work can tremendously impact the effectiveness of a forensic laboratory.

Ethics

Professional ethics provide the basis for the examination of evidence and the reporting of analytical results by blending the scientific principles and the statutory requirements into guidelines for professional behavior. Laboratory managers must strive to ensure that forensic science is conducted in accordance with sound scientific principles and within the framework of the statutory requirements to which forensic professionals are responsible.

Expert Witness Tips

Forensic practitioners are often called to court to testify as expert witnesses. Testifying in court is a challenge, particularly, for an inexperienced person. Training and experience eventually make it easier. The following are some hints for effective expert witness testimony:

Before Going to Court

- Keep thorough notes, records, photos, diagrams, etc.
- Carefully prepare your reports and consider appropriate language, completeness, and opinions.
- Prepare your prosecutor through a pretrial conference.
- Review the case before you arrive in court.
- Never allow a prosecutor or defense attorney to push you beyond your area of expertise or opinion. Ask yourself, can my testimony withstand the evaluation of a competent opposing expert?

Giving Expert Testimony

- Dress the part of an expert. Wear conservative clothing. Avoid wearing lapel pins or jewelry that designates membership in a club, group, or religion. Your appearance carries a tremendous amount of weight in how well juries are willing to believe what you say.
- When answering questions, respond to the jury, not the lawyer. Talk to the jury and make eye contact. Look at the individual jurors.
- Sit up straight. Do not slouch or look too comfortable.

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- Pause before giving your answer. Give the opposing counsel a chance to object. Also, consider what you are going to say.
- Try to avoid "ums" and "ahs" when speaking.
- Present a professional demeanor. Not only what you say is important, but also how you say it and how you look saying it.
- Be aware of your physical presence — how you sit, and your body language. Do not fumble with exhibits or props; watch out for change in pockets.
- Do not fidget or sway when standing.
- Watch your demeanor. Do not appear too confident (it may be construed as arrogance).
- Avoid animosity. Appear sincere, objective, polite, and fair. Concede, if you do not know the answer.
- Listen to your speech, volume, and pace. Be deliberate, but not slow.
- Present your opinions with *emphasis.* Educate using nontechnical language. Use analogies. Make your testimony interesting!
- Concentrate: listen to every word of counsel. Do not jump the gun with your replies.
- Pause to clarify concepts.
- REMEMBER: A court reporter is recording everything you say. Be specific when giving your testimony.
- Respond directly to the question.

Cross Examination

- The witness dictates the pace. You do not need to answer any question yes or no. Explain your rationale.
- Be careful with questions such as "Is it possible that …?" or "Is it fair to say?"
- It is acceptable to say, "I don't believe I am qualified to answer that question."
- Listen to all aspects of the hypothetical question. If you are unsure what the question is, ask for clarification.
- If you are not given a chance to explain your answer, ask if you can respond to clarify your statement.
- Remember your demeanor and attitude. You are not supposed to take sides.
- The louder and more belligerent the lawyer becomes, the more composed and polite you should become. Do not lose your temper.
- If you are asked a particularly lengthy, confusing question simply say, "I don't understand your question. Could you rephrase it?"

Other Points

- Speak in a manner that lay people can understand. Avoid jargon, especially "scientific-ese."
- Go over prior testimony, reports, and exhibits before the trial. Try to have a pretrial conference with the prosecutor.
- Remember the KISS Principle and keep it simple!
- Be objective. You are not an advocate. It should not matter to you whether the case results in a guilty or not guilty verdict. Your salary will stay the same. *Your job is to be an advocate for* ***your*** *opinion.*

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- Use visual aids, analogies, illustrations from everyday life, and the chalkboard.
- Pay attention to the judge. Objection sustained means you cannot answer the previous question.
- Do not box yourself into a corner. Beware of questions like, "Have you ever made a mistake" and "Isn't it possible?"
- Do not try to avoid a difficult question. Juries are suspicious of evasive answers.
- Be aware of the cross-examination trick of taking an excerpt from a publication out of context or an excerpt from a *nonexistent article.* You can always ask the lawyer to show you the article to refresh your memory or even to read.
- Be able to say, "I don't know" or "I was wrong."
- Take the lead to meet with and talk with counsel.
- Mentor new, inexperienced prosecutors. If he or she is new or inexperienced in a given area, be patient and offer your assistance as an expert. Try to remember how you felt the first few times you appeared in court.

Teamwork

The final element in crime scene investigation is teamwork. The investigation of criminal acts involves scores of people who often work for different agencies. This system was purposefully designed so that no one person or entity can operate independently. As such, turf issues will always arise — *This is my responsibility; you are not supposed to do that.* In addition, as we move to larger and more complex criminal justice systems, we are more likely to be dealing with people who are faceless voices at the other end of the telephone.

For any complex systems to work, teamwork is essential. Each element of the criminal investigation —uniformed officer, detective, crime scene specialist, forensic scientist, coroner, forensic pathologist, photographer, prosecutor, plus all the other vital players in the "system" — must work cooperatively with the other elements to make the entire process work.

No one element or person is more important than any other person or element. Each person has a vital role to play and each portion of the case must be accomplished in a responsible, professional and timely manner to make every component function properly. Everyone working on a case should feel that he or she is essential to the successful completion of an investigation. Each must feel empowered to do what needs to be done, if only for the sake of justice. Prima donnas have no place in this process!

This chapter has introduced some of the major concepts concerning physical evidence, including its definition and value, the difference between identification and individualization, a brief discussion of the collection and preservation of physical evidence, ethical conduct, and teamwork. Subsequent chapters will explore these topics in greater detail as they relate to specific types of evidence and investigations.

Professional Development

Crime scene investigation, forensic identification, and forensic science require continuing education and networking with other professionals. It is unthinkable, for example, that a physician, dentist, accountant or lawyer would not maintain ongoing study though

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professional conferences and continuing education. This is equally true in the forensic science professions.

Law enforcement agencies employ most crime scene investigators and forensic identification and forensic science professionals. Many police agencies fund continuing education in their annual budgets at amounts between $1000 and $1500 per testifying practitioner. This economic commitment is essential to the ongoing professionalism of practitioners and is used for professional association dues, professional conferences, and continuing education.

The International Association for Identification is one of the oldest professional associations of its kind. For professionals engaged in crime scene work, it is an excellent vehicle to maintain competency in this field. The IAI publishes the *Journal of Forensic Identification* and holds an annual seminar that brings colleagues together to attend workshops and technical presentations and to exchange information. The IAI is worthy of consideration for membership for any serious practitioner. Many state divisions of the IAI also may be explored.

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First Officer at the Crime Scene

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The Case of the Lady in Cement

In late 1987, the skeletal remains of a middle-aged woman, unceremoniously labeled “Jane Doe No. 9,” were found buried in the foundation of a residence in the Pacific area of the city of Los Angeles. Examination indicated she had died of multiple stab wounds. The upper portion of her body was encased in cement, a factor that led to her identification through a variety of unusual scientific measures. The wet cement that had flowed over her body had settled in a vivid outline of her skull. This allowed the composite artist of the Los Angeles Police Department, Scientific Investigation Division, to cast a death mask of the victim. The mask and artist’s rendering presented a startling likeness to the victim, who was ultimately identified (Figure 2.1).

When the drawing appeared on television a citizen produced a photograph of a woman resembling the drawing. This led to the possible name of the victim. A fingerprint card was found on file because she had been fingerprinted for a routine job application.

Her arms, crossed over her body, left telltale finger holes in the cement where her hands had rested. Portions of the cement were surprisingly smooth textured, leading to speculation that the preservation of fingerprint evidence might be possible.

After experimenting with various substances, the Latent Print Section determined that rubber silicone was superior because of its high tensile strength and other properties necessary for detail enhancement. Silicone was carefully poured into each hand mold and allowed to dry. The cast was then painstakingly removed from the mold. The silicone casts bore ridge detail of the fingers and palm that enabled the Latent Print Section to make a positive identification of the victim. Just as dramatic were the casts’ clearly defined additional cuts and stab wounds on her hands and finger, probably as a result of defending herself at the time she was attacked by her killer (Figure 2.2).

Meanwhile, the concrete-walled grave in which the victim was found also contained items of clothing and other artifacts. The Comparative Analysis Unit

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Figure 2.1 Wet cement had flowed over the victim's body creating an outline of her skull (A), which allowed the LAPD composite artist to cast a death mask (B) of the victim. The mask and artist's rendering (C) presented a likeness of the victim.

was able to pin down a meaningful estimate of an entombment date to provide detectives with a time frame in which to target their investigation. They determined that the most likely item found with the body for dating was a partly deteriorated cigarette package. The name of the manufacturer, Liggett & Myers (L&M), was discernible. A partial reconstruction of the deteriorated package was necessary to determine additional package characteristics, such as the style, color, location, and content of the imprinted information, tax seal dimensions, and package components. Detailed photographs were taken to record the pertinent information.

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Figure 2.1 (continued)

As part of a test market in March, 1974, in the Liggett & Myers western region (California, Arizona, New Mexico, Colorado, Nevada, Idaho, Montana, Wyoming, North and South Dakota, Washington, Oregon, and Utah) the company had introduced a soft pack of L&M "longs." The product was withdrawn in March, 1975, and the L&M packaging was changed. Furthermore, the tax-stamp dimensions, affixed to a package by the local wholesaler, were consistent with the type used in California (Figure 2.3).

This narrow time frame of 1 year, bracketed by March, 1974, and March, 1975, when the cigarette package was marketed and probably purchased, helped detectives

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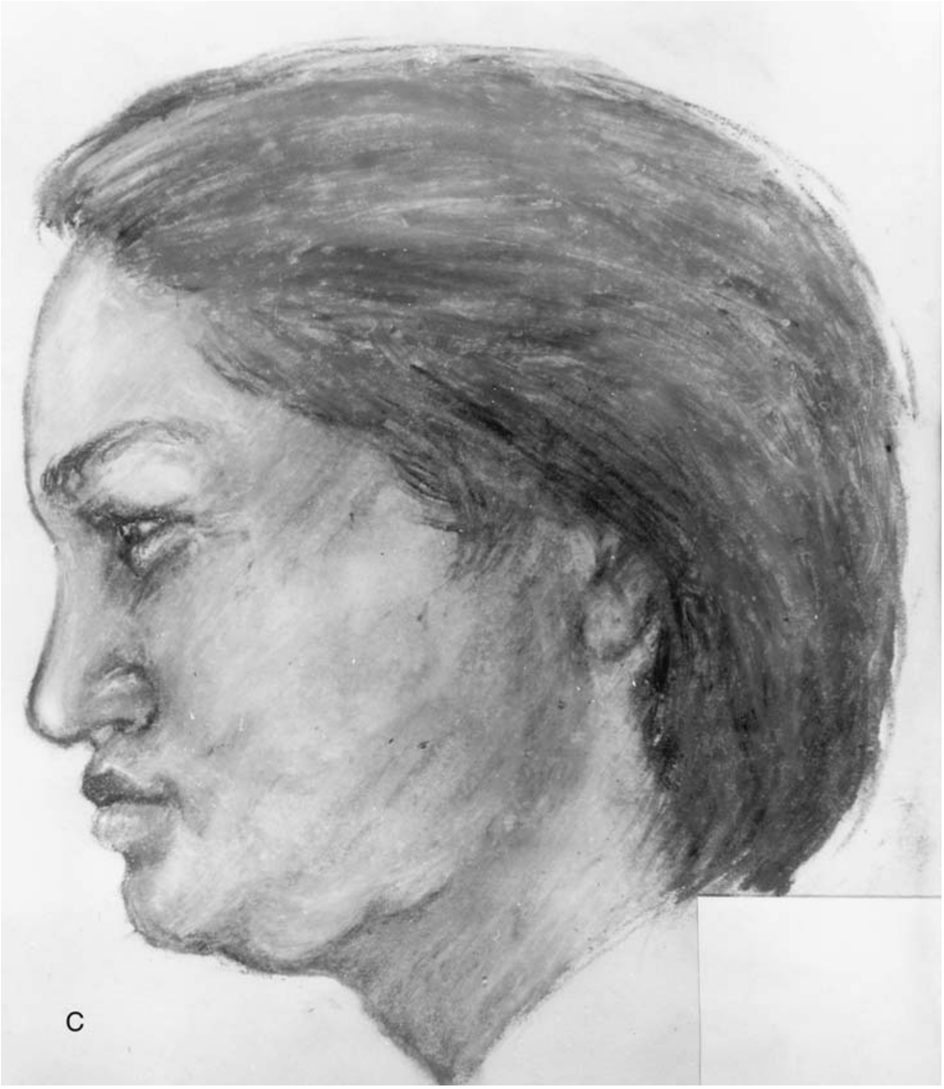

Figure 2.1 (continued)

target a suspect who had access to the house during that time span. Although other items of evidence were available and dramatically important in this particular case, the cigarette package clearly demonstrated the hidden potential of physical evidence. Murder charges were filed against the suspect.

The First Officer at the Scene

Crime scenes are dynamic, rapidly changing environments and the first officers to arrive on the scene must be concerned with countless details. To a great extent, the success of the investigation and, perhaps, the chance for a successful resolution of the case hinge on actions and steps taken by the first officer to arrive at the crime scene.

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Figure 2.2 The silicone casts contained sufficient detail on the fingers and palm to enable a positive identification of the victim. The casts also clearly showed additional cuts and stab wounds on her hands and finger, a result of defending herself at the time she was attacked by her killer.

The crime scene is the locale from which the majority of the physical evidence associated with the crime is obtained. It provides investigators with a starting point for the inquiry to determine the identities of the suspect and victim and to piece together the circumstances of what happened during the crime. Physical evidence found at the scene can be the key to the solution of the crime. The first officer's most important task at the scene is to prevent the destruction or diminished value of potential evidence that may lead to the apprehension of the criminal and the ultimate resolution of the crime.

The responsibility of the first uniformed officers at the scene should not be minimized. What these officers do or do not do, whether innocent or intentional, may have serious consequences to the investigation. Some police agencies have very specific policies for uniformed personnel concerning their duties and responsibilities at the crime scene. First responders should be familiar with those duties and responsibilities and execute their jobs to the best of their ability. Superior officers and training officers should monitor the performance of both new and experienced uniformed personnel. Police agencies should

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Figure 2.3 The concrete-walled grave also contained items of clothing and other artifacts. One artifact was a partly deteriorated cigarette package showing the name of the manufacturer, Liggett & Myers (L&M). L&M had test marketed a menthol long cigarette soft pack in March, 1974, in their western region, which included California. The product was withdrawn in March, 1975. *(Los Angeles Police Department.)*

understand the importance of ongoing training and continuing education, not only for investigative and technical personnel, but for first-responding personnel as well.

The duties of the first officer to arrive at the crime scene are the same, regardless of the rank, and remain the same regardless of the seriousness of the crime. The first responder at the scene must assume that the criminal left clues or physical evidence. The first responder's actions or inactions should not destroy or change anything at the scene. Information developed from evidence left at the scene may help to reconstruct the crime or prove the identity of the suspect. Furthermore, the first officer must not inadvertently add material that may mislead investigators.

Common sense strongly suggests that a crime scene will yield useful information. It is not possible for anyone to enter a place without changing it in some way, either by bringing something to it or removing something from it. The idea of a person changing a scene is known as the *Locard Exchange Principle*. Although changes to a crime scene may be exceptionally small, the course of an investigation may well hinge on their detection. Therefore, the first officer's action or inaction may affect the future of the investigation.

The value of detailed, meticulous note taking throughout all phases of the case cannot be overemphasized. All officers have many jobs to perform during the beginning phases

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of an investigation. Police handle many investigations and it is not inconceivable for one case to blur into another — a very human reaction. Thorough, detailed note taking, i.e., recording significant as well as mundane observations at the time they are noticed, is the most effective way to minimize loss of information.

Naturally, a general rule of protecting the crime scene cannot be applied in every case. The resources of the individual law enforcement agency as well as the nature of the crime must be taken into account. Petty thefts and similar misdemeanors will not receive the same in-depth investigation as a case involving murder, rape, or assault. Some police agencies may arbitrarily set a lower limit to the property value lost in a burglary as a way to determine the scope of their investigation.

In certain serious crimes, it may not be possible to preserve the crime scene because of the location. A busy street or highway with heavy traffic is an example of a situation in which it may not be possible to protect a crime scene properly for a sufficient period of time. In situations like this, the deciding factor in safeguarding the crime scene concerns the likelihood that the criminal has left clues that can be recovered vs. the negative factors of holding up traffic flow. Each case must be decided on its own merits.

At first glance, the actions to be taken by the first officers on the scene may seem simple and not well beyond the scope of routine police duties. Some further examination of these duties will show that this is not the case.

First of all, first responders should not approach the scene in haste. All movements should be calm and deliberate. Officers should expect the worst and take the position that it is better to be overly cautious and remember the popular wisdom: *if something can go wrong, it will!* Approaching the assignment with an open mind helps an officer avoid carelessness and false moves that may prove to be disastrous.

Mistakes made during the interrogation and other aspects of the preliminary investigation can perhaps be corrected; but errors committed in the protection and examination of the crime scene may never be set right. The eventual success of the investigation may be dependent on the preventative and preliminary measures taken by the first officer to arrive at the crime scene. Unfortunately, there are too many examples of how an omission or a mistake on the part of the first responder proved fatal to the investigation and resulted in an unsolved crime.

In a difficult situation, the officer may be faced with a dilemma that requires quick analysis of the circumstances and taking appropriate steps. However, if the basic rule of always anticipating the worst and taking extensive rather than minimal precautions is followed, the most serious errors can usually be avoided.

Because conditions and situations can vary greatly from one crime scene to another, it is not possible to set hard and fast rules. However, certain guidelines can be established. These are mainly applicable to homicide cases and other serious crimes because it is in just these cases that the officer is faced with the most difficult tasks and the actions taken have the most far-reaching consequences. These rules are applicable to less serious crimes as well.

Recording the Time

Precise notations of the time are very important in an investigation. They are most important for checking a suspect's story and can often be quite important in other consequences

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as well. Therefore, the first officer at the scene should write down arrival times and other times that may turn out to be important. Notation should be made of the time that the crime was committed, the time that the officer was first called, the time of arrival at the scene, and so on. Such notations lend precision and credibility to the officer's statement if testifying in court should become necessary. Keeping track of the time spent at the scene also maintains a chronological record of the way things were done during the crime scene investigation. These notes will prove invaluable if specifics about the investigation should be needed after the actual event.

Entering the Scene Proper

When entering the scene, the officer should try to form an estimate of the situation — what happened here — as quickly as possible. This estimate is the basis for any subsequent actions. When entering the scene proper, or the focal point of events, the officer must proceed with extreme caution and concentrate attention on possible evidence that may be found on doors, doorknobs, light switches, floors, and other areas.

An effort must be made to observe details, particularly those that are fleeting, and to take written notes on such points as:

- Doors — open, closed, or locked? On which side was the key?
- Windows — open or closed? Were they locked?
- Lights — on or off? Which lights were on?
- Shades, shutters, or blinds — open or closed?
- Odors — cigarette smoke, gas, gun powder, perfume, etc.?
- Signs of activity — meal preparation, dishes in the sink, house clean or dirty, etc.?
- Date and time indicators — mail, newspapers, dates on milk cartons, stopped clocks, spoiled foods, items that should have been hot or cold but were at room temperature

Nothing at the crime scene should be moved initially unless absolutely necessary. The crime scene should remain as close as possible to its original condition when the detective or investigating officers arrive. If it becomes necessary to remove any object because others may disturb it, the officer should consider the possibility that the item may have fingerprints present and act accordingly. Before any object is moved, its location should be noted. The exact position of an object at a scene may become important later in the case. Its position should be noted in the report, outlined in chalk, sketched, photographed, or videotaped.

Under no circumstances should anyone be allowed to wander about the crime scene simply to satisfy his curiosity or pick up and handle objects. Regrettably, there have been too many instances where first officers arrived at the scene and toured it, leaving fingerprints on a variety of surfaces. Such carelessness cannot be tolerated.

Those at the crime scene should not use the toilet, turn on water, eat, drink, smoke, or use towels. The criminal may have used any of these objects — a towel could have been used to wipe a bloodstained weapon. Evidence may have been caught in the sink trap. The rule is simple: the first officer at the crime scene should not touch anything unless absolutely necessary or unless he is charged with the responsibility of processing the scene for physical

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evidence. First officers should consider it embarrassing to have their fingerprints found and identified at the crime scene.

First officers should understand that they may be called on later by the investigator or detective to account for every movement made at the crime scene. This may be necessary in order for the investigating officer to get a better idea of the original condition of the crime scene proper or to explain seemingly out-of-place items at the scene.

On occasion, the victim or a relative may attempt to clean up the scene — perhaps to put everything in proper order when the police arrive or to try to conceal something. Occasionally, cleaning serves a psychological need to put everything back in its place. If a clean-up is in progress when the officer arrives, it should be stopped. If the clean-up has been completed or the officer suspects that is the case, a detailed inquiry should be made to determine the original condition of the scene. It may be possible to recover material or undamaged items that were thrown out.

Protecting the Integrity of the Scene

As soon as possible after arriving, the officer should take steps to protect the scene from anyone not directly involved with the investigation, including other officers, supervisors and command personnel, the press, curiosity seekers, and family members. This is no easy task and sometimes requires some ingenuity because, initially, personnel may be insufficient to protect the crime scene (Figure 2.4).

Simply locking a door or stringing rope or commercially available crime scene tape around the perimeter can secure the crime scene. If these measures do not suffice, first responders may resort to using vehicles, boards, or furniture gathered from another area away from the scene to help keep curiosity seekers out. Even with devices such as police barricades, yellow crime scene tape, and ropes, officers may still need to take an active role in keeping unauthorized people away.

The extent of any protective measures must be decided on a case-by-case basis. As a general rule, if the scene is indoors, the barricade should include the central scene and, where possible, the probable entry and exit paths used by the criminal. In this connection, it is important to focus attention on potential evidence on the ground outside a window, in rooms through which the criminal had to pass, in stairways, or in entrances.

If the location is outdoors, an ample area should be roped off to include the paths taken by the criminal to and from the crime scene proper. Sometimes, critical evidence may by found on or near a route leading to or away from the scene. It is important to search paths carefully. In some cases, prior to the arrival of the police, onlookers trample the crime scene.

In open areas, a dependable barricade can be set up only if an officer is stationed outside the perimeter. The protection of the scene in this case merely requires that the officer not walk around aimlessly inside or immediately outside the roped-off area. Limiting movements permits later accountability for the officer's own tracks.

The first officer should remain at the scene whenever possible and should send others to call headquarters or detective personnel. Leaving the supervision of the crime scene to persons other than police officers should only be done in exceptional circumstances. Protective measures at the scene should be taken as early as possible to prevent valuable, often vital evidence from being destroyed. It is also important that barricades be sufficiently

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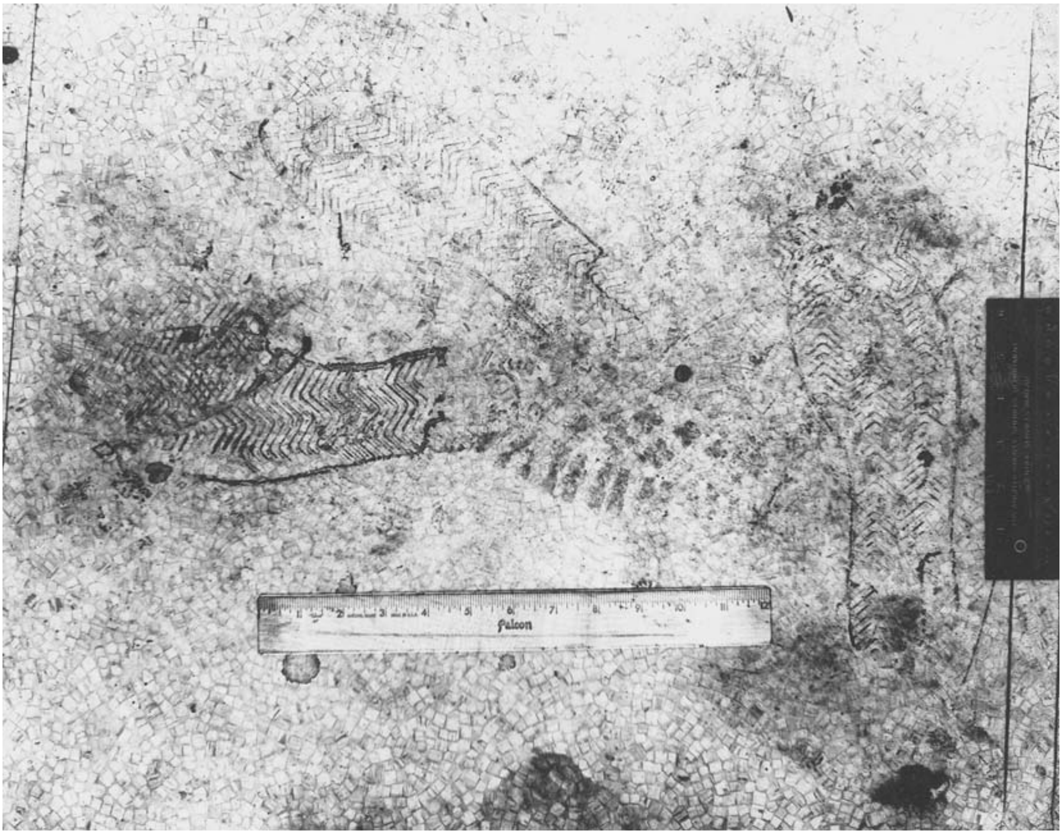

Figure 2.4 Uniformed officers must take care when securing the scene. This officer did not and consequently superimposed his shoe prints over those of the suspect. *(Los Angeles County Sheriff's Department.)*

extensive from the beginning of the investigation. Sometimes, a sufficient area around the crime scene is not protected early enough in the investigation.

When large outdoor areas are to be protected, officers may take the initiative by enlisting the aid of police cadets, police reserves or others who can be trusted to assume responsibility for protecting the scene.

Injured Person on the Scene

Saving lives is the first priority and takes precedence over all other considerations. If an injured person is on the scene, first aid should be administered immediately even if it means valuable evidence may be lost or destroyed. If first aid to the injured is not immediately essential, the officer should note the victim's position on a simple sketch, by marking the floor, or by forming a mental picture of the position. The officer should note how the victim is lying or sitting, the position of the hands, arms, and legs, the condition of clothes, and so on. It is also important to notice if the victim's hands have anything in them such as hairs, fibers, etc.

When paramedical or emergency medical personnel arrive, the officer should — without interfering in their work — instruct them how to enter the scene without disturbing

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it unnecessarily. Observing the movements of medical personnel and noting whether any objects were moved is a necessary task.

If civilian emergency medical personnel transport the injured person, a police officer should accompany the victim. An alert investigator may hear an important word or accusation or what might be equivalent to a dying declaration that might be the key to the entire case. In one case, a dying woman uttered the name of her assailant. This vital information fell on the untrained, inattentive ears of the civilian emergency medical personnel and no amount of interviewing could sharpen their recall.

The officer should arrange for proper removal and custody of the victim's clothing. Occasionally, when the hospital or mortuary is contacted to obtain the victim's garments, the clothing has been incinerated or wadded into a hopeless mess after being cut from the body. Representatives of police agencies should make periodic visits to local hospitals to instruct medical personnel in the proper handling of evidence. The medical profession's lack of interest in and knowledge about evidence is disheartening, considering the broad range of their training and the media attention to criminal investigations.

Dead Person on the Scene

If the first officer on the scene is able to establish certain signs of death, such as clear rigor mortis, odor, lividity, beginning decomposition, and so forth, the body is not to be touched or removed until a detailed examination can be made. Once the first officer at the crime scene has established that the victim is dead and has made a cursory inspection of the crime scene, superiors must be notified regarding the nature of the case. A telephone should be used for this purpose rather than a police radio because it is not uncommon for the press and other news sources to monitor police radio frequencies.

Summoning the Coroner

Whether the medical examiner or coroner should be contacted at this point of the investigation is a matter of local custom. Some agencies, by agreement with the coroner or medical examiner's office, first wait for the investigating officers to arrive and begin their investigation. Notification of a death may be made at this time, with an estimate of the time the coroner should arrive. This can save the coroner's staff time by not having to wait needlessly at the scene until the police have completed their portion of the investigation. Policies should be arranged with the medical examiner's or coroner's office on such call-out matters.

The medical examiner–coroner's or coroner's office generally has jurisdiction over the body at the crime scene. Where this jurisdiction is in effect, the body may not be moved or searched without prior consent of the medical examiner–coroner.

On rare occasions, the first officer must take immediate steps to remove the body from the scene. In these situations, the officer must ensure that the deceased is placed on the stretcher in the same position in which the body was discovered, provided that circumstances permit. Limbs rigidly fixed in a certain position should not be straightened. If the victim is found face down, the body should remain in that position because lividity may change position and appearance, and trickles of blood may change direction.

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If the rigidity must be broken in order to transport the body, the officer must make note of it, preferably with sketches or photographs showing the original position. Before the body is moved, its position must be marked on the floor, on a sketch and photographed. It is important that the position of the head, arms, hands, knees, and feet is shown on the sketch. The officer should also note the condition of the clothes and bloody tracks that may be present. This can be extremely important in answering the question of whether the body had previously been moved. Blood may run while the body is being removed. A question may later arise about the source of this secondary flow of blood.

Suspicious Death

A woman was found dead on the floor in her bedroom. The first officer at the scene made a superficial examination of the scene. Some of the deceased's relatives stated that the woman had been very ill. Concluding that she had died of natural causes, the officer had the body removed from the scene without examining it further. After the deceased was moved, it became apparent that she had died of strangulation. A scarf had been tightly wound around the neck three times and knotted at the throat. A trickle of blood had run over one cheek from the mouth in an upward direction in relation to the position of the head at the time of the brief examination. The investigation of the case was complicated and impossible to decide because of the officer's premature decision to allow the body to be removed. It never could be established whether the blood flowed during or before transportation.

In cases of strangulation or hanging where unmistakable signs of death are observed, the first officer at the scene should do nothing to the body. If there is a danger that the rope might break, the officer may attempt to support the corpse, but it should not be cut down. If obvious signs of life are present, the officer must try to save the person.

Knots in ropes should not be untied, if possible. The knot may be typical of a certain occupation or skill level. The noose may be cut and the loose ends labeled appropriately. An alternative to labeling is to tie the ends back together with string or thread. If these materials are not available, the noose or rope should be placed so that the officer can later recall which ends belong together. In emergencies, the knot may be loosened somewhat and the noose pulled over the victim's head. It is also important to remember which end of the rope was anchored to a fixed object or pulled over a branch or beam. The direction of distorted surface fibers on the rope may indicate whether the victim was pulled up because it is always possible that a hanging was arranged to cover up a murder.

Firearms and Ammunition on the Scene

The general rule is that any firearms or ammunition should be left untouched until investigating personnel arrive. However, recovery of weapons and ammunition may become necessary. If they may be inadvertently moved or lost during the removal of an

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injured person, or if conditions are such that the first officer cannot effectively protect the scene alone and bystanders might disturb the evidence, then the evidence may be removed.

When weapons are recovered, the officer should concentrate on the possibility that valuable evidence may be found on cartridge cases as well as on weapons. If there is reason to believe that fingerprints are present in oil or grease on a weapon found at an outdoor crime scene in cold weather, the weapon should not be moved to a heated room; the heat may destroy the evidence.

When picking up pistols and revolvers, a pencil or a stick should never be inserted into the barrel in order to lift the weapon. Dust, blood, particles of tissue, and other debris in the barrel may become dislodged. To move a hand gun, grasp the checkered surface of the grips with two fingers to lift the weapon. Fingerprints will not be deposited on the grips. If the grips have a lanyard ring attachment, the gun can be lifted by the ring. Before the weapon is recovered, its position should be marked on a sketch or by outlining its position on the floor. This marking is important. There might also be a mark in the floor under the weapon, indicating that the gun fell from the hand of a suicide. The position of bullets and cartridge cases may reveal the direction of the shot and possibly the location of the assailant. The positions of hammer and safeties should be noted (Figures 2.5 and 2.6).

Suspicious Death

A man with a bullet wound in his head was found in his apartment. A police officer and emergency medical personnel transported the dying man to a hospital where he was pronounced dead on arrival. The officer accompanied the injured person to the hospital, which complicated the investigation because the first officer was not available to communicate any information to detectives, who immediately began an investigation of the apartment.

A bullet and cartridge case were found in the room where the victim had apparently been shot, but a weapon was not located. An automatic pistol was found on a shelf in the hallway and appeared to have been recently fired. A suspicion of murder arose because the injured man could not have placed the gun there. Thus began a thorough and time-consuming examination of the apartment. After the first officer who had gone to the hospital was questioned, the case was determined to be a suicide. The first officer had found the gun by the victim and, without thinking of the consequences, examined it and placed it on the shelf before leaving the apartment. If the investigators had known the facts from the first witness — the first officer — much time and effort could have been saved. Certainly, the detectives acted properly by assuming the worst; however, the first officer at the scene failed to brief the investigators adequately.

If a weapon is found, it should be in the same condition in which it was recovered when delivered to a firearms examiner for examination. When the firearm is packaged for submission as evidence, a detailed description of what was done to it may be prepared and sent to the crime laboratory. The first officer should not pull the slide back on a pistol or turn the cylinder of a revolver, nor touch the trigger or the safety catch. The only

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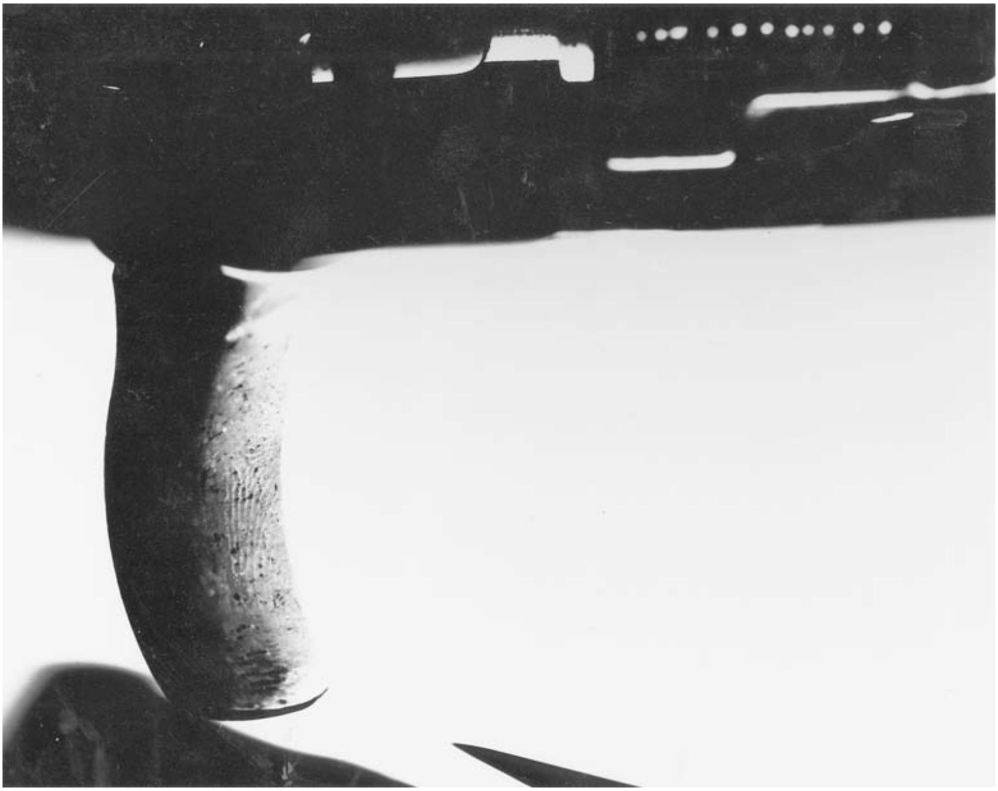

Figure 2.5 A suspect discharged a weapon in a Fairbanks, Alaska, nightclub and subsequently fled, discarding the gun in the snow. A previously convicted felon was interviewed about the crime but denied any knowledge or ownership of a weapon. A latent print was developed using cyanoacrylate ester and photographed using direct reflective lighting. The felon's prints were compared with a latent print on the trigger and identified. He was charged with "Felon in Possession of a Firearm." *(State of Alaska, Scientific Crime Detection Laboratory, Latent Print Section.)*

acceptable changes to the weapon would be to remove a cartridge from the chamber or mark the position of the cylinder. Only a person with firearms experience should render the weapon safe.

When a Suspect Is Found at the Scene

The first officer to arrive at a crime scene may need to arrest or detain a suspect. In such cases, the most important duties should be done first. The police officer must use common sense in taking whatever measures are necessary in order to protect the scene. If it is not possible to hold the suspect at the scene or in the police vehicle, a possible alternative is to find a reliable person to protect the scene until other officers arrive. The first officer must instruct such persons on how to guard the premises because the task is likely to be unusual for them.

The first officer should also be aware that the longer the suspect remains at the crime scene, the greater the possibility becomes of changing or contaminating the crime scene. The suspect could, for example, remove evidence, leave new evidence or even gain

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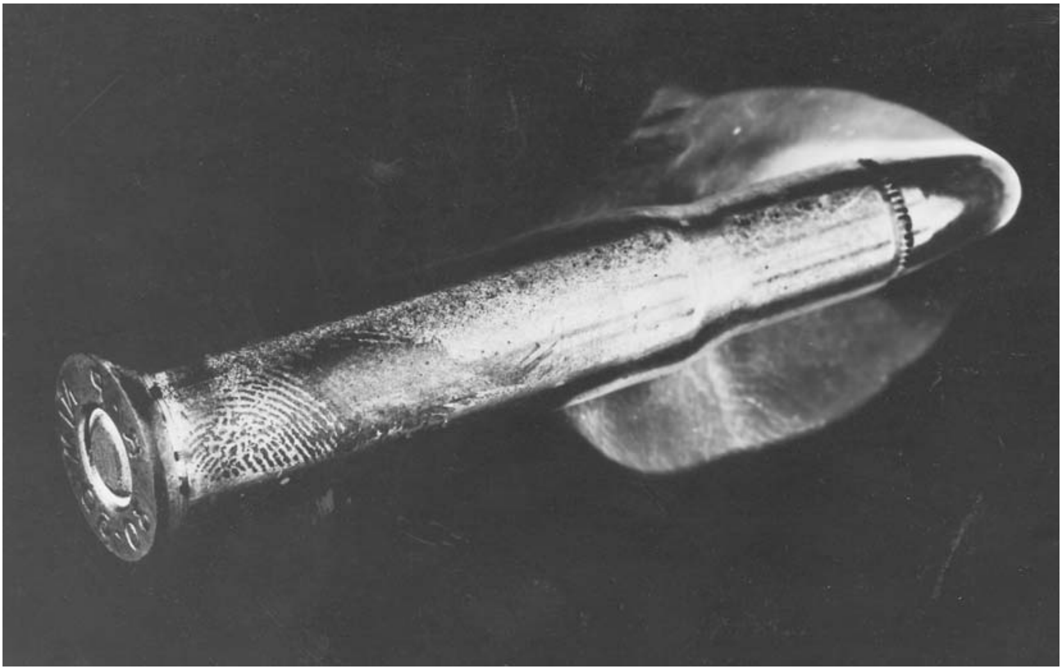

Figure 2.6 This latent print was developed with cyanoacrylate fuming. The 30.30 caliber bullet was recovered from inside a loaded rifle magazine; the crime involved the shooting death of an elderly white male. The photographic technique employed "shadow" photography and inner negative reversal of the ridge color. The reader is referred to the article on shadow photography in the *Journal of Forensic Identification* 38(5) Sept./Oct., 1989. *(State of Alaska, Scientific Crime Detection Laboratory, Latent Print Section.)*

information from the opportunity of observing the scene in detail. The suspect should be searched and removed from the location as quickly as possible.

What to Do Until Investigating Personnel Arrive

While waiting for investigators to arrive, the officer should attend to the following:

- **Write down names of witnesses and other persons who entered the scene.** This is important for the subsequent sorting of fingerprints and other clues found at the scene.
- **Note who was at the scene when the officer arrived.** This information can become particularly important if the crime has just occurred.
- **Establish the basic facts.** A factual account of what happened is of great assistance to the detectives when they arrive because it helps them decide on the next move. However, the officer should never undertake lengthy and detailed interrogations that may damage later questioning or give rise to misleading suggestions in the statements of witnesses. Furthermore, the officer cannot properly guard the scene if occupied with interrogations.
- **Keep the suspect and witnesses separated wherever possible.** Allowing the suspect and witnesses to talk may interfere with later questioning. Family members may

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be left in the care of neighbors when necessary, taking care that no alcoholic drinks or sedatives are administered. Remember that the dramatically grieving relative may be the prime suspect.

- **Instruct witnesses not to discuss the events.** This can prevent distortion by suggestion. If possible, the principal witnesses should be separated. In relating events to one another, witnesses may distort each other's impressions to a point at which they believe that they saw things that they really did not see or that never happened.
- **Do not discuss the crime with witnesses or bystanders.** This is also intended to prevent suggestion and distortion. Furthermore, circulating details of the crime may hinder the investigation.
- **Listen attentively, but unobtrusively.** An alert officer can often pick up information of vital importance to the investigation simply by being a good listener.
- **Protect evidence that is in danger of being destroyed.** During inclement weather such as rain or snow, divert water and cover tracks with boxes, cardboard, etc. If the crowd of onlookers becomes large, it may become necessary to expand the protective measures at a given location to prevent trampling of the evidence.

When the investigating officers arrive, the first officer should report all that has been learned and observed and the actions taken. This is very important to the evaluation and planning of the crime scene investigation. It is particularly important that reports be given of the extent to which the scene has been altered and whether objects have been disturbed or moved.

Continued Protection of the Scene

In protecting the scene after the investigators have arrived, the officers detailed to protect it should act only on orders from the detective in charge. During the technical examination of the scene, it is the crime scene investigator who is in charge of the officers on security duty as well as of the scene proper.

No one should be allowed access to the crime scene without the investigator's permission, not even other investigators or superior officers. Command officers would render a fine service to their investigators if they would preserve the integrity of the crime scene with a passion and set an example for other officers by keeping out of the scene. Those allowed on the scene must move with their hands in their pockets so as not to touch anything. Through carelessness or without even being aware of it, they may touch objects on the scene. The explanation might be that a desire to do something prompts them to touch objects that should not be touched before they have been examined. Wearing gloves should not be permitted at the crime scene (except in cases where quantities of blood or other biological fluid is present and infectious diseases are a concern). People wearing gloves are more likely to become careless and touch objects that may have fingerprints and thereby destroy them or render them useless.

Unfortunately, there are numerous instances of police officers on sightseeing tours through crime scenes. Sometimes they destroy more evidence than any group of lay people could possibly accomplish. At one crime scene, it was reported that the presence of one more police official would have threatened the collapse of the building. Even experienced

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Figure 2.7 The suspect stated that he had never been in the murder victim's house in Ninilchik, Alaska. Trash from the victim's wastebaskets was examined for latent prints. A print was developed on the ring tab of a beer can using cyanoacrylate ester fuming. The latent print was compared to and identified with the suspect in the case. *(State of Alaska, Scientific Crime Detection Laboratory, Latent Print Section.)*

investigators are guilty of allowing these tours, especially in murder cases and other serious crimes.

News reporters sometimes arrive at the scene before the officers who are to examine it. People in the neighborhood usually call them or they may have heard a call on the police radio. The first officers on the scene should not, under any circumstances, give information about the case to reporters. To inform the press is the responsibility of the police chief, sheriff, or officers designated by them. Officers should not favor one reporter or news agency by giving out information that may not be available to the competitors through prescribed channels. In dealing with reporters, officers should be neither curt nor nonchalant, but they should be firm, even when reporters are persistent. The officer should remember that reporters often give invaluable assistance in the investigation of major crimes. Press passes should be disregarded during the protection of a crime scene.

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Crime Scene Dos and Don'ts

Do	Don't
Limit access to the crime scene by using tape and a major incident log.	Permit unnecessary personnel to enter the crime scene.
Attempt to identify possible routes used by the suspect.	Use routes possibly used by the suspect.
Note original conditions at the crime scene.	Assume others will note original conditions, etc.
Record changes in conditions especially in regard to your activities (or paramedics').	Fail to document any changes or contamination at the scene.
Protect evidence from adverse environmental conditions.	Allow evidence to be compromised by nature
Conduct all administrative duties outside the tape (coffee drinking, smoking).	Eat or use any facilities or the phone within the crime scene.
Record the location of evidence before moving it.	Remove items and package without documentation.
Package trace evidence (paint, glass, etc.) into large envelopes.	Package trace evidence in a bundle.
Keep an open mind as to what might be evidence.	Ignore items that appear out of place or are difficult to explain.
Be aware that you are a potential source of evidence.	Touch anything unnecessarily.
Take photographs of items at 90° with and without L-scales.	Photograph items only without scales.
Call expert personnel to crime scenes for detailed or difficult collection or documentation.	Assume the expert can always answer the questions from nonexpert collection or documentation.
Take photographs of all aspects of crime scenes, perspective shots, 90° photos of items and bloodstains.	Limit your photos to overalls and item locations.

This list was developed by Ronald Linhart and Elizabeth Devine, Los Angeles County Sheriff's Crime Laboratory.

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The Crime Scene Investigator

3

Case

The body of an 18-year-old female was found on the side of a road near Porvoo (a small city about 50 km northeast of Helsinki, Finland). The deceased was completely naked from the waist down and the upper part of her body was clothed normally. The victim's jeans, stockings and underwear were bundled on her chest. The technical research team took the clothing of the deceased, fingernail scrapings, head hair and pubic hair combings, and known hair standards as samples.

Fiber evidence was found in the victim's hair. The autopsy determined that the cause of death was strangulation and that the victim had been raped. Semen was found in vaginal and rectal samples taken during the autopsy and the ABO blood group A was determined. The victim's blood group was type A. The hope of solving the case centered on the fiber evidence and an initial hypothesis was made that the fibers must have had something to do with the crime. Eleven brown uniform and multicolored acrylic fibers were found from the combed hair samples. Similar fibers were collected from tape lift samples taken from the clothes of the victim. About 200 fibers were found in the clothes. With the help of reference samples, it was deduced that these fibers most probably originated from the seat cover of a car. The police were advised that the laboratory was especially interested in brown automobile seat covers made from a pile-type material and that, while searching cars, they should give special attention to red textiles (Figure 3.1).

From the samples combed from the victim's head and pubic hair, two and three thick viscose fibers were found, respectively, that were unusual in their color and dyeing. The victim's clothes yielded 28 similar fibers. In the combed samples an orange-red woolen fiber was found that was about 3 cm long; 13 similar fibers were found in the clothes. Because of the number of red-colored fibers found, it was possible to consider primary transfer. It was assumed that the origin of the fibers must have been from a textile other than clothes worn by the suspect because neither of the fiber types belonged to typical cloth textile types (Figure 3.2).

The technical research team examined 12 cars over a 2-month period. They collected seat covers that were a possible match to the fibers, picked hairs and

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Figure 3.1 (A) The roadside near Porvoo where the body was discovered; (B) the body was discovered partially clothed; (C) a close-up of the victim.

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Figure 3.1 (continued)

Figure 3.2 The police eventually located the suspect's car, partly because of leads the laboratory was able to provide concerning the seat cover.

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Figure 3.3 (A) A search of the suspect's home yielded fibers similar to those found on the victim; (B) fibers from the fabric on the couch and woolen blanket on the sofa proved to be important evidence in the criminal prosecution.

fibers, taped the seats and searched for the victim's fingerprints. The fiber samples taken from the victim did not match the samples taken from these cars. The victim's clothes were white and light blue and made mainly of cotton; therefore, it was pointless to try to collect these types of fibers.

The 13th car to be examined belonged to a person who, 9 years earlier, had been charged with rape but released due to insufficient evidence. The suspect was also a type A secretor. The seat cover material in his car matched the acrylic fibers from the hair and the clothes of the victim. Also, the samples taken from the seat covers contained similar red-colored viscose and woolen fibers found on the samples taken from the victim. Thirty-nine samples were taken from the interior furnishing textiles in the suspect's residence and also from his clothes. The red viscose fibers proved to be the same as the pillowcase cloth fibers found on the sofa in the living room of the suspect's residence. The red woolen fibers were the same as fibers from a blanket found on the sofa (Figure 3.3).

The samples taken from the victim's hair, pubic hair, fingernail scrapings, and clothes were compared with the fiber samples taken from textile materials in furnishings in the suspect's residence and from his clothes. The victim's hair yielded 13 dark blue cotton fibers; one of the same type was found in her fingernail scrapings. These fibers could not be differentiated from the fibers taken from the suspect's blue trousers. In the clothes of the victim, three thick yellowish-brown V-shaped viscose fibers were found. Their color, quality, thickness, shape, and size were the same as plush fibers found on a velvet sofa cover in the suspect's residence. The sixth fiber similarity between the samples taken from the victim and samples taken from the suspect's residence was pink acrylic fibers, of which three found in

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Figure 3.3 (continued)

the victim's clothes were similar to the fibers of a sweater in the suspect's residence. All of the different types of fibers were found in the suspect's car seat cover and clothing.

During the investigation, it was concluded that the victim had not been to the suspect's residence but the suspect's untidy habits transferred the fibers from his residence to his car, which was a secondary transfer. None of these fibers were found at the victim's residence, on her clothes, or at her mother's home. Polarizing light microscopy, fluorescence microscopy, and microspectrophotometry were used in the fiber identification. FTIR spectroscopy was used to investigate the brown acrylic fibers. The accused did not confess to the crime but admitted that only he used his car. He was convicted and sentenced to 10 years on the basis of evidence produced by the fiber investigation.

Most police departments today use uniformed or patrol divisions as well as detectives in crime scene processing. The patrol officer, who is usually the first police officer to respond to the crime scene, and the detective, who may arrive later, are responsible for the investigation and processing of the crime scene. This division of labor by function is useful because it allows for a certain degree of specialization and hence the likelihood of better performance in the respective responsibilities. Although patrol or detective personnel may be used for crime scene processing in serious crimes, many police agencies delegate to detectives and/or specialists, such as crime scene investigators, fingerprint specialists, or forensic scientists, the crime scene search and collection and preservation of physical evidence. Patrol or uniformed officers may process crime scenes in less serious crimes. Uniformed officers often respond to residential burglary scenes to investigate the crime,

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take a report, photograph the crime scene, dust for latent fingerprints, and collect evidence, without calling a detective or using specialized personnel such as crime scene evidence technicians. However, in major criminal investigations — such as homicides, rapes, assaults, and robberies — personnel with more extensive training and experience are most likely to be used in processing crime scenes.

Although different law enforcement personnel may process the crime scene, the rules are the same in all cases. Crime scenes contain potent information that, if sought in a systematic, legal, and scientific way, can help the investigator determine what happened, who was responsible, and who was involved. Law enforcement personnel involved in criminal investigations must be able to derive the maximum possible information from the crime scene.

The objectives of a crime scene investigation are to:

- Reconstruct the incident
- Ascertain the sequence of events
- Determine the mode of operation
- Uncover a motive
- Discover what property was stolen
- Find out all that the criminal may have done
- Recover physical evidence of the crime

In some cases, the investigation yields results that point directly to the criminal and provide solid evidence against the offender. Generally, this happens when the perpetrator's fingerprints are found at the scene and the prints are already on file. Such cases happen infrequently, but the use of *AFIS,* Automated Fingerprint Identification Systems, has greatly improved the chances of identifying the criminal and many cold cases have been solved through AFIS technology.

The work of crime scene investigators[1] is frequently thankless. Often the public and police officers think of them as a modern day incarnation of Sherlock Holmes or one of several popular characters on television portraying crime scene investigators. Some expect that real-life crime scene investigators are capable of magically establishing complete information on the identity of the criminal and solving the crime quickly, as television is able to do within the hour allotted to the usual TV show. When a crime scene investigator does not succeed in doing just that, he may be considered unsuccessful. This attitude is, of course, ridiculous. It is the duty of detectives to pursue and apprehend the criminal; the duty of the crime scene investigator is to gather all evidence available at the scene. For the investigative process to function best, the detective and the crime scene investigator need to work cooperatively. Each must consider the other as part of the team.

The notion of teamwork in criminal investigations is a key factor to a case's solution. Each person in the process plays a vital role. Any one individual can do something that has disastrous consequences to a case or makes a significant contribution. No one, including the uniformed police officer, the detective, the forensic specialist, the medical examiner, or the prosecutor, can fulfill his duty without the cooperation and assistance of all the other people on the team.

[1] As used in this chapter and elsewhere in this book, the term "crime scene investigator" refers to a specialist whose principal job is to identify, collect, and retrieve physical evidence from the crime scene or to a detective or investigator who has the collateral duty of collecting and preserving physical evidence.

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Crime scene investigators understand that criminals leave trace evidence behind and take away minute material from the scene and/or victim. The crime scene investigator's job is to find these traces and preserve them. Such evidence may be used to reconstruct the crime or to prove that the suspect committed a criminal act. The value of any item of evidence to a criminal investigation — such as an apparently unimportant object or fact — may turn out to be extremely important later in the investigation. No item, however small, should be overlooked.

The crime scene investigator's job at the scene is similar to that of the first police officer to arrive on the scene. Each must proceed calmly and deliberately. The crime scene investigator should not approach the task with preconceived ideas or draw premature conclusions. Investigators should scrutinize the scene with their eyes open for details. Experience teaches the investigator to expect the worst[2] and to be more thorough than needed. A good rule to remember is: *It is better to have processed the scene more thoroughly than needed than to have overlooked something seemingly insignificant that later turns out to be a critical item of evidence in the investigation*. A complete investigation may produce information that substantiates a confession or refutes a defense contention raised at the trial. Mistakes made during the investigation often may never be rectified.

Naturally, making the statement, "investigations should be conducted as thoroughly and carefully as possible," belies the fact that investigators are only human. Even experienced, dedicated professionals make mistakes. Remember that conducting thorough investigations is a goal for which to strive. Even with the best of intentions, mistakes and oversights may occur.

The O. J. Simpson case is a classic example of how the actions of investigators can be misconstrued. During the trial, the defense team raised questions about the crime scene practices of the police and even cited a prior edition of this textbook to suggest that the police acted improperly in processing the scene. An important lesson from this case is that appearance and perception, as well as the ability to communicate effectively to a jury, are equally important. Appearances and perception are every bit as important as knowledge, skills, and ability, at least in the eyes of the jury and the public. If the defense can make it appear that evidence was handled in an improper manner, the jury may agree.

There are few absolute rules in crime scene investigations. An important concept to note is that most rules outlined in this text and others are guidelines, based on common sense, that are applied to crime scene investigation. There are always cases where guidelines cannot be followed. An example is packaging wet, bloody evidence in plastic trash bags. Wet, biological evidence packaged in plastic bags deteriorates more quickly than air-dried evidence and should not be used. However, when faced with a crime scene with blood-soaked clothing or bedding, separate packaging in a clean plastic trash bag for immediate transportation to a crime laboratory is an appropriate way to handle such items if the evidence cannot be dried at the scene. Situations demand that investigators be flexible and creative when necessary.

Because investigators are human beings, it is impossible for them to conduct investigations without making mistakes. It is necessary to try to make as few errors as possible and to learn from past faults. Unfortunately, critics will always have a compelling urge to

[2] Those new to crime scene investigations will do well to consider the wise sayings found in the folk wisdom of *Murphy's Law*: 1) If something can go wrong it will and 2) If there is a worst time for something to happen, it will, at that time!

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be "Monday-morning quarterbacks" and advise any who will listen about how something should have been done. An investigator would be wealthy if he could have a dollar for each time he said, "If only I had thought to collect that item of evidence" or "I should have done 'thus and so' a different way" or "Why didn't I think of that at the time; it seems so obvious now." The adage that "hindsight is always 20–20" is a fact of life. Through experience, the same mistakes should not be made again. It is a good practice to ask if anything more should be done before quitting a crime scene.

A further lesson to be learned from the Simpson case is that the focus of forensic science is shifting from the laboratory to the crime scene. The crime scene investigation process is taking on a more prominent role. Defense attorneys are quick to learn that, if they can show that the initial handling of the physical evidence at the crime scene was faulty and calls into question subsequent lab work, the evidence may be kept out of the trial or at least tarnished in the eyes of the jury.

Crime scene investigators should not allow superiors or others at the scene to influence their deliberations on the case before or during the actual crime scene examination. The investigation should not be rushed, if possible. Others must wait. The investigator is personally responsible for his mistakes and has the right to determine personal actions at the scene.

An experienced crime scene investigator asked to explain how he proceeds at a scene may find this difficult to explain. Each crime scene is different and it may not be possible to lay down absolute rules for conducting an investigation; however, a generalized outline on how to process a scene can be made to fit a vast number of conditions. No matter how experienced an investigator is, there are always new situations to be faced and completely unfamiliar problems to master. The best advice to give in an extraordinary situation is to be calm, adaptable, and flexible.

The essential qualities of a good crime scene investigator are intuition and an eye for what needs to be done in every individual case, along with a thorough knowledge of the methods of locating and preserving physical evidence. Before any actual work at the scene begins, an investigator should try to stand back at an appropriate vantage point on the periphery of the scene and formulate a systematic plan, considering:

- How the search should be conducted
- What needs to be photographed at the scene
- Where the possible sources of physical evidence are

Following this initial assessment, the crime scene investigation can begin.

The start of the crime scene investigation begins with documenting the scene. This process includes:

- Photography and/or videotaping (overall views)
- The investigation of the crime scene proper (when needed, combined with photography and videotaping detailed views)
- Sketching (detailed sketches may be required during the investigation)
- Note taking (to be done throughout the investigation — constant interruptions for notes are the rule)

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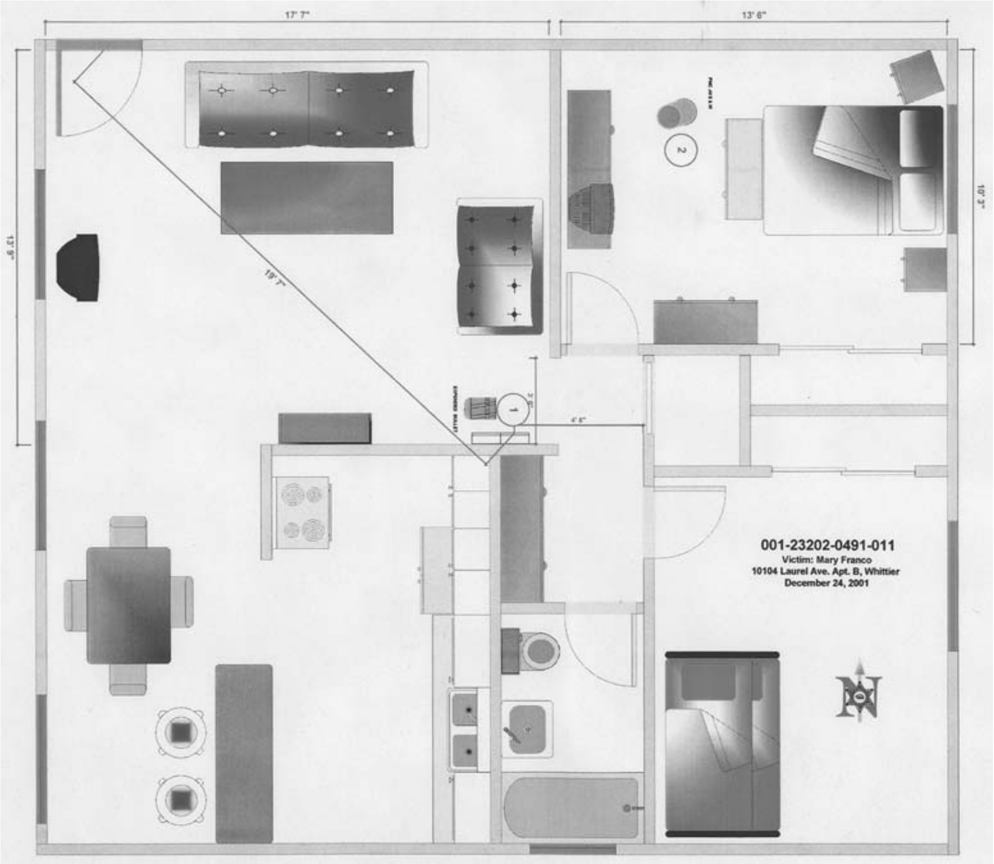

Figure 3.4 (A color version of this figure follows page 256.) Computer-aided drawing (CAD) programs continue to gain wide use in crime scene documentation. They provide an effective tool for investigators and aid juries in understanding the crime scene. *(Los Angeles County Sheriff's Department.)*

Note taking at a crime scene is essential. Well-written, contemporaneous notes are invaluable later in the investigation and especially at the time of trial. It can be extremely frustrating for an officer assigned an old open case if the case notes of the original investigator's initial observations are inadequate or even shoddy. There are no substitutes for good note taking at all phases of the investigation.

The order in which work is done at a scene is not sacrosanct. The rule is to be flexible and to use common sense. Sometimes an investigator must examine a detailed part of a scene or make a sketch of an object that had to be moved immediately on arrival at the scene. Consequently, the order of the various phases of processing a crime scene must be decided on a case-by-case basis.

Investigators should adopt an air of curiosity about everything concerning the crime scene, even the smallest items. The perpetrator may have forgotten or dropped something. A seemingly innocuous item may become the decisive piece of evidence later in the investigation. All investigators should develop a healthy skepticism. Things often are not what they seem to be. Be critical and never accept conditions or appearances without first

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questioning them. Simulated crimes or crimes masquerading as accidents to cover up criminal activities do take place.

Actual Examination of the Scene

Investigators should think through and reconstruct the actions of the criminal. If the reconstruction does not make sense or if there are inconsistencies, consider starting over to reevaluate the sequence of events. One way to proceed is to eliminate scenarios while reasoning that "it couldn't have been done this way." Continue the process until one or two possibilities remain.

A useful suggestion is to carry a few pieces of chalk or crayons in the crime scene equipment kit. If it becomes necessary to move an object, the location of the object can be marked with chalk, pencil, or crayon.

Examining an outdoor crime scene at night should be avoided, unless there is a compelling reason. Daylight, outdoor crime scene searches are more effectively examined, yield more information, and are easier to conduct. If an outdoor search must be conducted at night using artificial lighting, the scene should be kept intact as long as possible for a final search in daylight. No matter how powerful the lighting equipment, daylight is better. Experience teaches that some evidence, invariably missed in artificial light searches, is more readily detectable in daylight.

A crime scene investigation should not start if it is obvious that specialized personnel need to be called in to take over the job. The crime scene specialist's task is complicated enough and does not need to be made more difficult by the necessity of finishing what someone else began. The specialist should be permitted to take charge of the intact crime scene after being fully briefed by the detective in charge of the investigation. This guarantees the best possible results.

"Two heads are better than one" — using two crime scene investigators to search for and collect physical evidence is the most effective staffing level for most major crime scene investigations. A single crime scene investigator can do an effective job of searching for and collecting physical evidence, but two are better. Two investigators are more thorough. Notwithstanding this recommendation, in some instances just one investigator will suffice. Emergency circumstances and small, limited crime scenes are such examples. The crime scene investigator may call on an officer who has experience in photography to photograph the scene. Similarly, the investigator may use uniformed police and detectives as assistants to help with some of the simpler tasks. However, this practice should only be used when temporary assistants can be supervised closely and given detailed instructions.

The two crime scene investigators should be used to working on crime scenes together and should be able to cooperate. They should work as a team rather than on separate tasks. One way to divide the work is for one investigator to do the actual examination while the other keeps notes and assists by making personal observations, making measurements and helping to examine a particular area. Two persons, working together, are able to observe much more than a single person can. Whatever one of the investigators discovers should immediately be reported to the partner. They also should discuss the different possibilities of how a certain clue might have been left at the scene and how the criminal proceeded. An idea that might not occur to one person may well occur to a second.

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In homicide cases and other serious assaults, crime scene specialists should not assume any other investigative duties. Their full attention should be devoted to the case in order to get the most from their efforts. If crime scene work and the detective functions are combined, one of the activities, typically the crime scene duties, usually suffers. Specialized personnel assigned to crime scene duties must cooperate closely with the detective in charge. This division of labor between duties of specialists personnel and detectives may not always be possible due to a lack of personnel. However, the two types of work should be separated whenever feasible.

On arriving at the scene, the crime scene investigator should first obtain the basic facts from the officers already present. It is important that crime scene investigators be well briefed about the case before starting their examination of the scene. Arrival times and weather conditions should be noted. It is also important to determine which persons had prior access to the scene and whether any changes in the original conditions occurred.

When entering the crime scene, investigators should proceed cautiously, aware of potential clues on floors, doorknobs, light switches, and other areas that may have been touched by the criminal. Even when chances are slight that evidence may be found, investigators should not dismiss the possibility that important evidence is present. Investigators should never walk about the crime scene aimlessly. They should exercise the same caution that is expected from inexperienced personnel. Even if many people have already trampled the crime scene, it is important to watch one's step. Although it might be excusable for untrained officers to destroy evidence by inadvertently handling items or stepping on items of evidence, such actions are unpardonable for experienced crime scene investigators.

Before starting work, investigators should first thoroughly consider the crime scene. Significant circumstances may be overlooked if the scene is not thoroughly evaluated first. The investigator should make a complete and systematic survey of the scene and its immediate surroundings, both indoors and outdoors. The investigator should attempt to reconstruct the actions of the criminal by constantly asking "why and how?" Why did the criminal do this, how was the building entered, how was this mark made? Distractions should not be allowed to interfere with the investigator's initial reconstruction of the case. Quiet deliberation is essential to planning the course of the investigation intelligently and getting the most information out of the scene.

Everything crime scene investigators learn during the investigation should be written down as it is discovered. Clear, concise, contemporaneous notes should be taken during the entirety of the examination. The location and description of objects should be recorded in the notes before they are moved or examined in detail. In some cases, before moving an item of evidence, it is helpful to make a detailed sketch and take close-up photographs with a scale or ruler in the photograph. Examination notes at the crime scene should be made in the order of the work done and should not be edited. Any editing and report writing should be done after the initial stage of the investigative process and, preferably, back at the office. The extent of the notes is somewhat proportionate to the seriousness of the crime; a burglary investigation may not merit as many detailed notes as a murder investigation. In the murder case, the statute of limitations never runs out, so notes must be complete enough to be understandable and helpful even 15 or 20 years later.[3] All objects and details pertinent to the description of the scene must be noted. The report of the investigation of a major crime can never be too detailed. The completeness of the report

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is especially important in crimes that are not solved within a reasonable time. Rough notes and sketches made at the scene should never be discarded but included with the case file.

Although the press has a legitimate role in reporting criminal activity, the media should not be permitted into the crime scene proper to photograph the actual scene without express permission from the officer in charge. In sensational crimes, news photographers will often try to photograph the crime scene and victims, along with police officers. Police personnel should not pose for such pictures; they usually look ridiculous. These news photographs only serve the doubtful purpose of satisfying the public's desire for sensationalism.

Personnel at the crime scene should never divulge specific information or conditions at the crime scene to reporters. In fact, only public affairs officers or lead detectives should speak to reporters at crime scenes. The general rule is not to give out essential information, which is key to the solution of the crime. Usually, only the criminal gains from these news accounts. In one high-profile serial murder case, at a press conference the mayor of a large U.S. city released critical information about unique shoe prints found at several crime scenes. Needless to say, those shoes were never located when the suspect was apprehended. Suspects in a criminal investigation may claim that they learned about particular facts relating to the case on television or in the newspapers. Such information should be given to the press only if it would assist the investigation, and only the officer in charge or a superior may give permission for its release. In cases in which the press becomes privy to sensitive information, they should be asked to hold off reporting it to the public in the interest of solving the case.

If paramedics have been called to the scene, they must be allowed to enter the crime scene whenever an injured person is present or when death has not been established with certainty. The crime scene investigator should ensure that paramedics do not unnecessarily destroy evidence.

If unmistakable signs of death (rigidity, lividity, odor, beginning decomposition, etc.) are present, paramedics need not be called. Once the first phase of the investigation has been completed, the coroner may be called. Investigators should work to cultivate good working relationships with their medical examiner and coroner's representatives. Close cooperation between the police and the coroner is requisite for successful investigations.

A crime scene investigation is characterized by three essential conditions for success: organization, thoroughness, and caution. Confusion, incompetence, and imprudence may result in a failed investigation.

Following the initial attempt at reconstructing the crime scene, the crime scene investigator's task is to photograph the central crime scene.[4] The actual investigation should follow with the central scene, unless an initial survey indicates that physical evidence is present along the route used by the criminal to enter or leave and this evidence cannot be well protected. In such cases, the investigator should first examine and recover these items

[3] The advent of forensic DNA typing and AFIS technology has had an interesting side effect. Murders committed 15 and 20 years ago are being solved. Computer systems storing DNA results and unidentified fingerprints wait patiently for a "hit." Unidentified criminals, whose DNA is tested and added to states' felon DNA databases or prints entered into AFIS databases because of an unrelated arrest, have been identified and many unsolved cases cleared, often to the criminal's surprise.

[4] The terms "central crime scene" and "crime scene proper" are interchangeable and refer to the area where the crime took place.

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of evidence before continuing at the central crime scene. The search of the criminal's route should start from the central scene.

In an indoor homicide scene, the central crime scene can be searched beginning with the criminal's suspected point of entry and point of exit, followed by the area adjacent to the body, and finishing with the rest of the room. Crime scene investigators should attempt to work according to an established routine that does not vary greatly from case to case. This helps to reduce the risk of overlooking a seemingly insignificant article of trace evidence or a larger object that the perpetrator may have left behind or accidentally dropped.

Investigators should not start the crime scene investigation with a detailed examination of the body until the basic examination of the scene has been completed. Other aspects of the crime scene may require attention first. Also, if investigators form a clear picture of the circumstances of the case by first examining the scene, the examination of the body might provide more information. Unknown facts may be discovered that are of value in relation to findings on the body. A preliminary inspection of the body to suggest the mode of death can precede the crime scene search. Noting a gunshot wound suggests that bullets or cartridges may be present. If investigators expect it will take a great deal of time to complete the initial crime scene search, body temperature and other time-of-death indicators should be collected.

Sometimes it is helpful to leave significant objects in their original positions during the investigation to aid in reconstructing the crime. This practice is useful if the reconstruction of events or the logical steps of the reconstruction do not mesh. If this happens, start over and retrace the steps in the thought process. The body should not be moved in haste if its presence is needed for the reconstruction. In some cases, it may even be appropriate to leave the corpse overnight, but consideration should be given to the availability of the forensic pathologist. If the autopsy can be performed right away, it should take place as soon as possible after the body's position is recorded. However, if the only purpose for moving the body is to place it in storage at a mortuary, this would be an error. Mere consideration of the dead should not influence the decision to move the body if further study at the crime scene is required.

At the very start of the investigation, investigators should designate an area as a "trash pile" in which things may be put that should not be lying about the scene. A certain amount of waste normally accumulates from empty film packs, blood-testing materials, etc. A work area is needed for filling out evidence tags, developing fingerprints on small objects, handling casting material, and so on. Although it is not proper to smoke at a crime scene, the rule is not inflexible, particularly when investigators are forced to work for long periods of time. The trash collection point should be located as far away as practical from the central crime scene. Spreading a newspaper or using a paper trash bag and marking it accordingly is enough to establish the trash pile.

For special methods of detecting, preserving, and evaluating evidence found at the crime scene, the reader is referred to subsequent chapters that deal with methods used at different kinds of crime scenes.

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Specialized Personnel at the Crime Scene

4

Uniformed officers and detectives do not possess the full range of special skills and expertise needed to process an entire crime scene. A wide range of specialized support personnel — some employed regularly and others occasionally — can provide these talents when called into a crime scene investigation. Sometimes a particularly serious case may warrant outside assistance, such as hazardous material specialists in the case of clandestine drug laboratory cases or federal authorities (e.g., Federal Bureau of Investigation, Bureau of Alcohol, Tobacco, and Firearms, or Drug Enforcement Administration) when investigating mass disasters, terrorist acts, bombings, or major fires.

Crime scene investigation (CSI) officers and evidence technicians are police or civilian personnel specially trained to process a crime scene.[1] These persons are equipped to collect and preserve physical evidence at a crime scene. They arrive at the scene with evidence collection kits and all tools and equipment needed to conduct the search and collect the evidence thoroughly.

There is no single classification of personnel or a sole way in which crime scene personnel are represented in public safety organizations. Some police departments employ identification (ID) officers. The ID officers photograph the crime scene and search for latent fingerprints; they may not be responsible for collecting other types of physical evidence at the crime scene. ID officers are generally experts in fingerprint collection and sometimes fingerprint comparison. They may be subpoenaed as expert witnesses to establish the identity of the suspect by comparison of latent fingerprints with inked prints.

Some cases may require an accurate architectural rendition of the crime scene. Forensic surveyors or other specially trained crime scene personnel may be used for this purpose. Relying on accurate measurements, notes, sketches, and photographs, they produce an architectural-like drawing of the crime scene for use at the trial. In some instances, three-dimensional models of the scene may be prepared to better assist the prosecution in presenting the case (Figure 4.2). Today, it is quite common to use computer programs to make accurate drawings of crime scenes.

Photographers are used for specialized photography. Aerial photographs may be needed to illustrate outdoor crime scenes. Unusual photographic problems such as low

[1] The International Association for Identification (IAI) offers a well-regarded certification program for crime scene investigators. More information is available at their web site: http://www.theiai.org/.

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Figure 4.1 (A color version of this figure follows page 256.) Crime labs frequently use standard cars, trucks and vans specially outfitted as crime scene vehicles. *(Los Angeles County Sheriff's Department.)*

levels of light, infrared photography, or aerial infrared photography may require their expertise (Figure 4.3).

Forensic photographers as well as police photographers are utilizing digital photography more for general police photography as well as crime scene photography. The increased resolution and decreased cost of digital cameras is driving this change. Considerations remain to be made before adopting digital cameras in lieu of film photography, but it is likely that, in a few years, digital photography will be the dominant still imaging technology in crime scene photography.

Videotaping is used by some law enforcement agencies as a means of recording crime scenes. Although affordable video units are available, the level of training required to take quality videos goes beyond the skills of a home hobbyist. Specialists require training to operate and maintain the sophisticated equipment necessary and to produce quality crime scene videotapes.

The criminalist, or forensic scientist, has special training and education in chemistry and biology that is applied to the recognition, identification, collection, and preservation of physical evidence. The criminalist is typically called on to assist in more serious criminal investigations such as homicides, assaults, bombings and arson. A criminalist's special area of expertise in these cases is trace evidence, biological evidence, and crime

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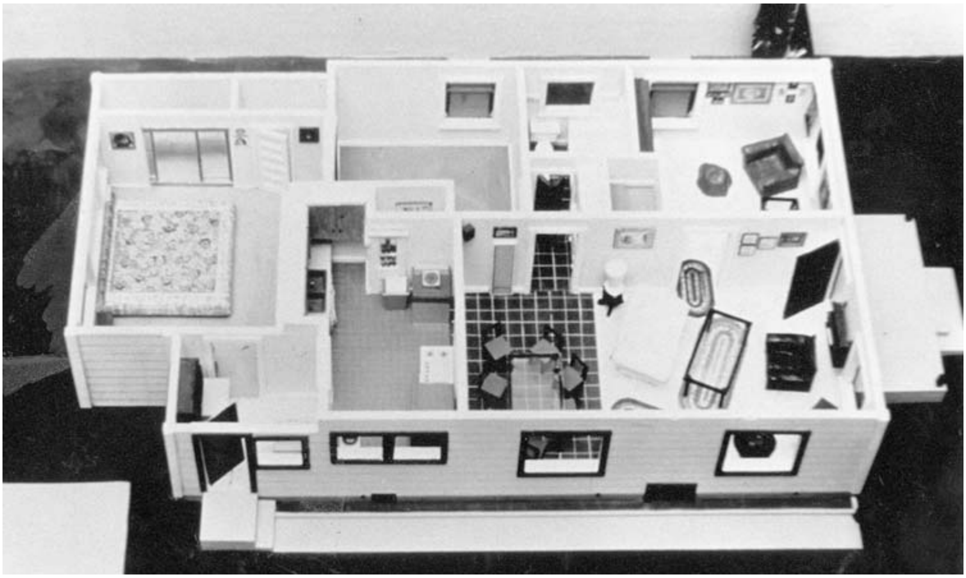

Figure 4.2 A three-dimensional mock-up of one of the crime scenes from the infamous Hillside Strangler Case in Los Angeles, California.

scene reconstruction. In addition to assisting at the crime scene, criminalists conduct laboratory tests on the evidence, prepare reports, and testify as expert witnesses on their findings.

State and local jurisdictions utilize a coroner system or a medical examiner. No standardized system is in place across the U.S.; however, most would argue that forensic pathologists have the training preferred for performing autopsies in criminal cases. The purpose of the medical examiner or coroner system in death investigation is twofold: to determine the cause of death and to identify the deceased.

The forensic pathologist or a trained investigator from the medical examiner's office is almost always called to the scene of a homicide as soon as the police investigator has completed the initial examination of the scene. It is the medical examiner's responsibility to identify the deceased, determine the approximate time of death, and take custody of the remains. Ideally, the forensic pathologist or coroner's investigator should be present at the crime scene to conduct an initial examination.

Hospital emergency room personnel may play an important role in gathering evidence in criminal investigations. Doctors and nurses who treat rape or assault victims often are required to collect physical evidence relating to the assault. Hospital emergency room personnel may not know which evidence is important or the legal requirements of evidence collection. The first officer to arrive at the scene of a rape, for example, may be required to inform the emergency room physician what evidence needs to be collected.

Forensic nurses are a relatively new group of professionals who provide a valuable resource to the police. They have training in nursing and in proper evidence collection as well as in other criminal justice-related skills. Today, most are found in hospital emergency room settings and collect sexual assault evidence as part of their duties. Expect to find more of them in other medical settings where evidence is collected for criminal investigations (Figure 4.4).

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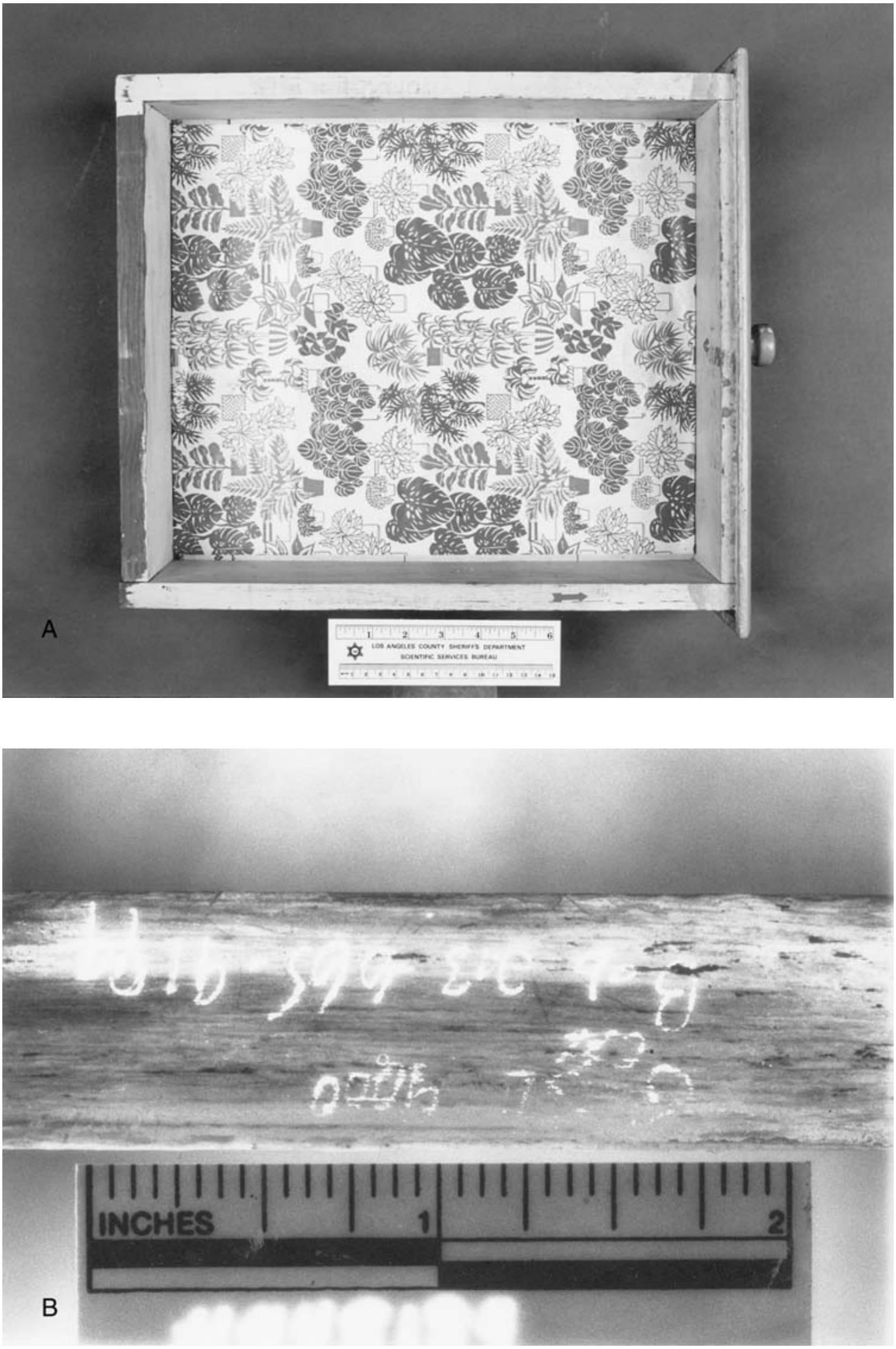

Figure 4.3 Photographic techniques using different lighting techniques can sometimes help to visualize important evidence. Writing discovered on the top inside portion of a drawer (A) was barely visible under normal lighting (a color version of this figure follows page 256). (B) Reflected infrared lighting enhanced the writing, making the telephone number visible. *(Los Angeles County Sheriff's Department.)*

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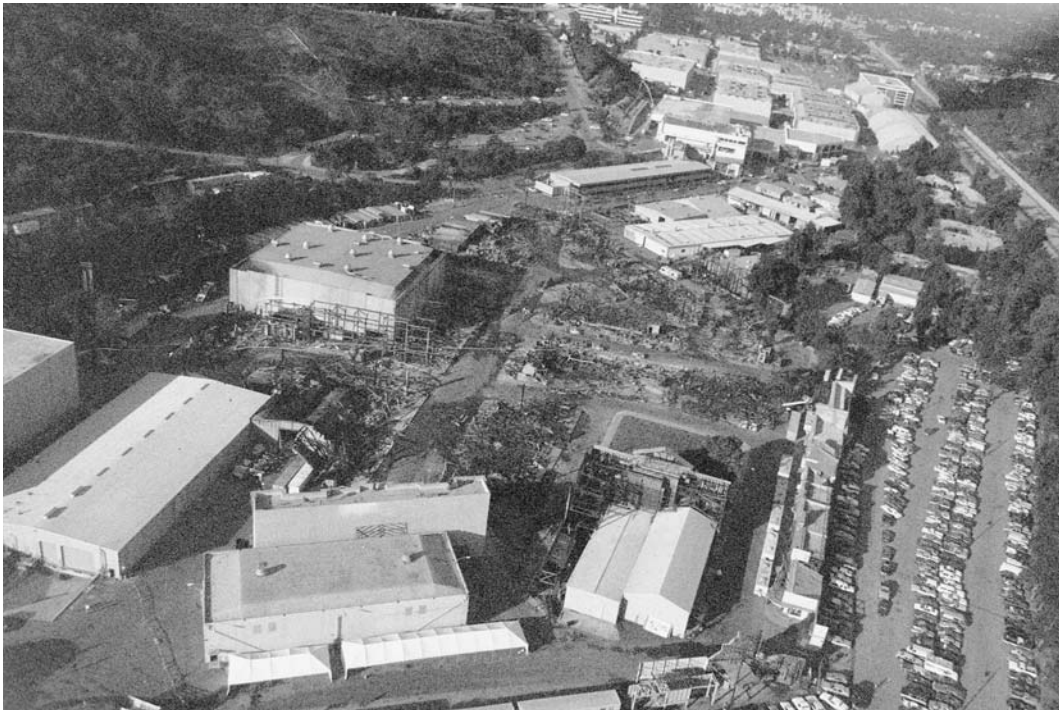

Figure 4.4 An aerial view of an arson fire at Universal Studios in Los Angeles, showing the extent of the devastation. *(Los Angeles County Sheriff's Department.)*

The district attorney may sometimes become a member of the crime scene investigation team. He or she may be called upon to obtain a search warrant for a location under investigation or a court order to obtain known specimens from a defendant.

In special cases, a forensic dentist may be called to a scene. Mass disasters such as plane crashes or scenes where charred remains are discovered require the expertise of forensic dentists to assist in identification by means of dental remains. They also may be called upon to collect and preserve bite-mark evidence on a victim or on foodstuff.

If the crime scene is a burial site, the assistance of a forensic anthropologist may prove valuable. The evaluation of skeletal remains at the scene is important in some instances. Also, excavating a grave site requires skill; experts with such experience can be helpful (Figure 4.5).

Cadaver dogs are specially trained to recognize the scent of decaying remains. They are useful for searching an area where investigators believe a body was buried to conceal a decedent.

Forensic psychologists are available to assist in evaluating a crime scene. One important group of trained personnel is through VICAP (violent criminal apprehension program). In cooperation with law enforcement agencies throughout the U.S., the FBI has raised VICAP to an important resource for crime solving. The agency is in the forefront of psychological profiling techniques and has trained hundreds of detectives across the country to review cases involving solved or unsolved murders or attempted murders. VICAP is appropriate in cases that involve an abduction and seemingly random, motiveless, or sexually oriented crimes or in known or suspected serial crimes. VICAP may be called in for missing person cases in circumstances in which foul play is suspected.

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Figure 4.5 A team of arson investigators and crime laboratory personnel examine the scene of the Universal Studios fire (note the use of the video recorder to document the crime scene). *(Los Angeles County Sheriff's Department.)*

Forensic engineers may play a role in studying the structural integrity of a building or other structure in an accident investigation. Sometimes, an item of building material may require engineering tests to determine if it was tampered with. Forensic engineers can be helpful in electrical fires, explosions, vehicle examinations involving traffic accidents, and investigations involving aircraft.

Forensic audio specialists may be required to evaluate sound recordings or to assist in reconstructing events by means of studying sound recordings of an event. Sometimes echoes can be used to pinpoint the location from which a weapon was fired.

Forensic toxicologists may become involved in product tampering cases to determine the nature of the adulterant in the foodstuff or consumer product. Using sophisticated laboratory instruments, they may be able to examine products for unknown poisons or other contaminants.

The Society of Forensic Toxicology (SOFT) defines three distinct elements of forensic toxicology as:

- **Postmortem forensic toxicology**, which determines the absence or presence of drugs and their metabolites, chemicals such as ethanol and other volatile substances, carbon monoxide and other gases, metals, and other toxic chemicals in human fluids and tissues, and evaluates their role as a determinant or contributory factor in the cause and manner of death

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Figure 4.6 (A color version of this figure follows page 256.) New technology such as this SCENESCOPE® ultraviolet light imaging system can assist crime scene technicians to visualize trace evidence, such as latent prints that fluoresce under ultraviolet light. *(SPEX Forensics www.scenescope.com.)*

- **Human-performance forensic toxicology**, which determines the absence or presence of ethanol and other drugs and chemicals in blood, breath or other appropriate specimens, and evaluates their role in modifying human performance or behavior
- **Forensic urine drug testing**, which determines the absence or presence of drugs and their metabolites in urine to demonstrate prior use or abuse

Firearms examiners are often called to assist in a crime scene to recover spent bullets from walls and doors and to assess the trajectory of fired weapons. They may also assist in determining whether a shooting could have been an accident or was more likely to have been intentional.

A consistent theme throughout this textbook is that police investigation is a team approach; professionals with multidisciplinary expertise are routinely brought together to solve crimes. It is not possible for a police investigator to have complete knowledge of the law, forensic science, and forensic medicine, as well as other training specialties needed to process a crime scene and investigate a crime completely. Investigators should maintain lists of local experts who can be readily mobilized to assist in cases. Such a directory is a major asset for successful police work.

The need for teamwork cannot be overemphasized. Throughout the case, the detective in charge will be responsible for pulling together a vast array of information from many sources. The detective's leadership skills are key to getting the maximum amount of information from those that may have been associated with the case from the crime scene portion of the case onward. Investigators who take the time to work closely with their

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Figure 4.7 (A) Hazardous materials are an ever-present possibility at crime scenes. Here, investigators suit up to enter a murder–suicide crime scene involving hydrogen cyanide gas (El Cajon Police Department Crime Laboratory, El Cajon, California). (B) Hazardous materials are regularly found at clandestine drug laboratories such as this methamphetamine laboratory (a color version of this figure follows page 256). *(Los Angeles County Sheriff's Department.)*

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Figure 4.8 An improvised explosive device was delivered by the U.S. Postal Service to the victim's mailbox. The victim stated that she opened the mail box and found a lacquered wooden box tied with a blue ribbon with a card on top. When she removed the ribbon and opened the box, the bomb exploded. The photograph is a reconstructed version of the bomb that was used to produce a list of the items used in construction of the bomb. *(U.S. Postal Service.)*

experts and maintain close working relationships with them will be rewarded by the extra effort.

Health and Safety Issues at Crime Scenes

The threat of chemical and biological terrorism as well as potential exposure to diseases at crime scenes requires unique expertise, which is sometimes not considered by police professionals. The following material is presented as a precaution. Awareness and proper care could save a life.

Chemical or Biological Terrorist Crime Scenes[2]

We live in a strange world where the unthinkable can become a reality. Because the threat of chemical and biological (as well as radiological and nuclear) terrorism is a reality and police and crime scene personnel may be called on as first responders, it is necessary to discuss this subject.

[2] Contact your local FBI office if you suspect you are dealing with a terrorism case.

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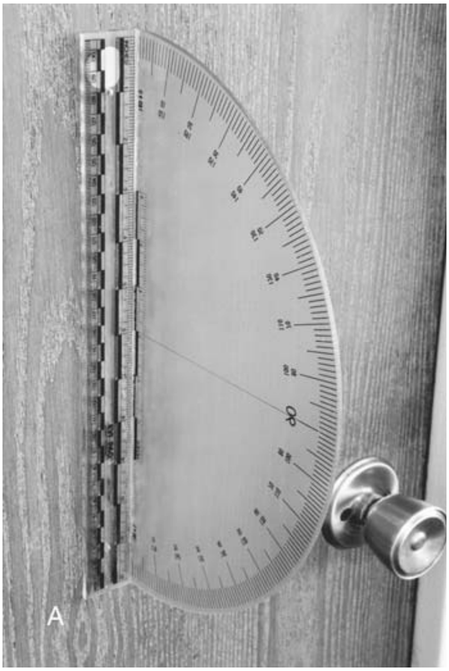

(A)

(B)

Figure 4.9 Commercially available devices can assist in documenting the crime scene. (A) A protractor used to measure the angle of a fired bullet through a door and (B) a laser mounted on a tripod are two ways to depict trajectory. *(EVI-PAQ, http://www.evipaq.com.)*

Ultimately, federal agencies, such as the Federal Bureau of Investigation, the Department of Homeland Security, the Department of Defense, Centers for Disease Control, and other organizations will be brought into a situation. However, local public safety agencies will be the first responders on the scene and first to assess the situation.

The following information is a cursory overview. Pre-incident planning and preparation are essential for personal safety in weapons of mass destruction, or WMD, situations.[3]

[3] The subject of first responders at WMD scenes is a very fluid topic. There are some excellent web sites for further information; see, for example: http://www.wmdfirstresponders.com/Index.htm.

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Figure 4.10 Body parts may be discovered in uninhabited areas, sometimes as a result of wild animal activity. A forensic anthropologist may be of assistance in developing information concerning identity from a skull. *(Los Angeles County Sheriff's Department.)*

Indicators of a Possible Biological Terrorist Threat

- Any reference to the terms "biological," "bacteriological," "germ," "microbe," "microorganism," "virus," "fungi," "bug," "vaccine," "antidote," "culture," "spores," or "vector"
- Any reference to the use of toxins, venoms, or poisons in relation to the development or use of weapons
- Any attempt to purchase or obtain information concerning biological cultures or spores from medical or research facilities
- Any information concerning the theft or attempted theft of biological cultures or spores from a university or medical research facility
- Any purchase or consideration to purchase laboratory supplies or specialized medical equipment
- Any attempt to acquire vaccines or medical antidotes against poisons or disease
- Any attempt to acquire any type of protective breathing apparatus or protective plastic, rubber, or charcoal-impregnated suit (these protective suits are not needed for biological agents)

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- Any indication of possession of, or an attempt to acquire, maps, photographs, or other information related to a public water supply, such as water treatment plants, reservoirs, or storage tanks
- Any reference to addresses of medical research facilities or mail-order companies
- Any indication of possession of, or attempt to acquire, maps, photographs, or other information related to architectural, building, or security plans of medical research facilities, including universities and private labs
- Any indication of the existence of an unusual infectious disease or other medical condition such as anthrax, botulism, or staphylococcal enterotoxemia in a locality where such a condition is not prevalent
- Any evidence of suspicious medical research activities, such as reports of rats, mice, rabbits, sheep, goats, or eggs at an incongruous location; the death of a large number of such animals in any locality; or the unexplained existence of medical protective garments, gloves, or medical face masks
- Any type of explosive device that contains an unexplained powder or liquid substance
- Any attempt to acquire meteorological data, such as temperature, humidity, or wind conditions, or any other relevant data contained in current weather forecasts

Indicators of Possible Chemical Terrorist Threat

- Any reference to the terms "chemical agent," "nerve agent," "blood agent," "blister agent," "choking agent," "mellowing agent," "incapacitant," "GA," "GB," "GD" "GF," "GH," "VE," or "VM"
- Any reference to the use of oxidizers, bleaches, or other decontaminates
- Any unexplained attempt to purchase bulk chemicals
- Any indication of an interest in the location of chemical manufacturing, storage, or distribution sites
- Any information concerning the theft or attempted theft of a tanker truck containing hazardous chemicals
- Any purchase of, or consideration to purchase, chemical-related laboratory supplies or equipment
- Any attempt to acquire antidotes against chemical nerve agents, such as atropine
- Any attempt to acquire any type of protective breathing apparatus or protective plastic, rubber, or charcoal-impregnated suit
- Any indication of the possession of, or an attempt to acquire, maps, photographs, or other information related to a public water supply, such as water treatment plants, reservoirs, or storage tanks
- Any indication of the possession of, or an attempt to acquire, maps, photographs, or other information related to architectural, building, or security plans of chemical manufacturing, storage, or distributing facilities
- Any unexplained report of individuals suffering from the symptoms of exposure to chemical agents, such as chemical burns or muscular seizures
- Any indication of unexplained or suspicious chemical accidents or spills

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- Any type of explosive device that contains an unexplained powder, solid, liquid, or gaseous substance
- Any attempt to acquire meteorological data, such as temperature, humidity, or wind condition, or any other relevant data contained in current weather forecasts

The nature of these crimes makes it imperative that law enforcement personnel appreciate the hazards of biological and chemical terrorist agents. Better to act on the safe side than to risk grave consequences.

Health and Safety Considerations for Crime Scene Personnel[4]

Crime scenes present potential safety risks to personnel. An understanding and appreciation of the potential risks coupled with appropriate safety precautions will minimize these risks. The following medical problems are listed as possible biohazards to law enforcement personnel and crime scene investigators. These nonroutine pathogens are not intended to include the "expected" human source blood-borne pathogens (e.g., AIDS and hepatitis viruses). Whenever an investigator has concerns about health symptoms, he or she should seek and obtain professional medical advice. Because it is presented in considerable detail, the following material is perhaps more information than the average reader may wish to review.

Anaphylactic shock is a life-threatening allergic reaction that may occur in people with extreme sensitivity to a particular allergen (e.g., insect sting). The reaction occurs most often following a direct injection into the bloodstream that provokes a massive release of histamine and other chemicals. Blood vessels dilate with a sudden loss of blood pressure (symptoms include itchy rash, breathing difficulty, and swollen tongue or throat). Severe reaction or collapse requires medical attention. First aid includes raising the legs above the head to improve blood flow to the heart and brain and CPR as appropriate. Individuals who have suffered severe reactions may be prescribed and carry preloaded epinephrine syringes for injection.

Hanta virus disease is found in rodent urine, feces, and saliva. Pulmonary syndrome Hanta virus symptoms begin as ordinary flu-like aches and pains and then develop into respiratory distress within 3 days (capillaries begin leaking); over a period of hours patients enter a critical phase in which it becomes progressively more difficult to breathe. Death may result from the loss of blood. Workers in a known area of contamination who develop fever or respiratory problems within 45 days from exposure should immediately seek medical attention and inform their physician of the potential occupational risk of Hanta virus infection. Rodents are the primary vectors although other small mammals can be infected. The deer mouse is the primary reservoir in the southwestern U.S., although serologic evidence of infection has also been found in pinion and brush mice as well as western chipmunks. Respiratory protection with at least a high-efficiency particulate air (HEPA) filter respirator[5] is a special precaution for workers (clean-up) in homes of persons

[4] This material was largely derived from the California Criminalistics Institute (CCI) and found on their web site located at: http://www.cci.ca.gov/Reference/NonRoutn.pdf.

[5] Note that there are specific OSHA requirements for personnel who use breathing equipment, including HEPA filter masks.

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with confirmed Hanta virus infection or buildings with heavy rodent infestations, and also for persons in affected areas who frequently handle or are exposed to rodents.

Lyme disease is caused by a bacterium/spirochete in rodents that is transferred to humans by tick bites. Symptoms include skin changes (red dot gradually expanding), flu-like symptoms, and joint inflammation. Treatment with antibiotics is more effective during early stages of a disease progression that may include the heart and nervous system.

Meningitis is caused by a variety of microorganisms. Viral meningitis is usually not serious and affects up to 12,000 people each year. Meningococcal meningitis is the most common bacterial meningitis, affecting up to 5000 young people (70% under age 5) each year. The meningococcal form is life threatening and needs prompt medical treatment. Symptoms include fever, severe headache, nausea and vomiting, dislike of light, and a stiff neck. Symptoms may develop rapidly over a few hours. A blotchy skin rash develops in about one half of the cases. In severe cases, confusion, delirium, seizures, coma, and shock occur. Although up to 40% of the population are nasopharyngeal carriers, very few develop the disease, which is transmitted by droplets. Patients receiving prompt medical treatment usually recover. Where close household contact (or mouth-to-mouth resuscitation) occurs, prophylactic antimicrobials can be effective. Pneumococcal meningitis is the most common cause of meningitis in adults and second most common cause in children over the age of 6.

Plague or the so-called Black Death was responsible for the deaths of 25 million people in the 14th century. Today, spring and summer rodent flea bites cause 10 to 50 cases per year, with the risk of death less than 5% after prompt treatment with antibiotics. A vaccination is available for individuals at high risk. The public health concern is that wild rats will pass the fleas to urban rodents, infecting people when the rat dies and the fleas leave the carcass. Symptoms of bubonic plague include: within 2 to 5 days, fever, shivering and severe headache, followed by "buboes" — smooth, oval, reddened, intensely painful swellings usually in the groin and less commonly in armpits and neck or elsewhere. Bleeding around the buboes leading to dark patches that may occur with occasional blood poisoning. Untreated, the disease is 50% fatal. Pneumonic plague may result as a complication of bubonic plague, causing severe coughing and producing blood, frothy sputum, and labored breathing; this is nearly always fatal unless diagnosed and treated early. The pneumonic plague can pass from person to person by infected droplets expelled during coughing.

Poison oak grows as vines or bushes and its leaves have three leaflets. The harmful oil resin, called urushiol, is also found in poison ivy and sumac. Touching results in itching, burning, and blistering at the site of contact. The response is not immediate and may occur 24 to 48 hours after contact. People with sensitivity may have extremely severe skin reactions. Prompt first aid (within 5 minutes of contact) by washing the affected area with soap and water may avoid a rash; sponging with alcohol is an alternative. After the rash develops, application of calamine lotion may help relieve itching and act as a drying agent. Corticosteroids may be recommended in severe cases (topically for small areas or by mouth if a large area is affected). Scratching or the watery liquid from the blisters does not spread the rash.

Pulmonary tuberculosis is caused by *Mycobacterium tuberculosis* and transmitted from person to person via an aerial route (other routes have been documented but none of major importance). Tubercle bacilli form nuclei for water droplets in respiratory secretions and are expelled during coughing, sneezing, and vocalizing. The moisture evaporates, leaving the desiccated bacilli airborne for long periods. Settled bacilli can absorb moisture

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from the environment and remain viable for weeks; they can be thrown back into air currents by walking through the room. Although the number of bacilli excreted is usually not large and household contact for many months is required for disease transmission, some infectious persons may be highly contagious because of the extent of disease (in the respiratory system), which relates to an increased concentration of expelled bacilli and frequency of coughing. Mycobacteria are susceptible to ultraviolet light and disease transmission rarely occurs out of doors in daylight. Increased fresh ventilation is the most important environmental measure to prevent disease transmission.

Initial infection is from one to three organisms that reach the deep lungs (alveoli) where they are ingested by scavenger cells in the blood (macrophages) and transported to regional lymph nodes, in which they are destroyed, or pass to the bloodstream, resulting in widespread dissemination. Surviving bacilli inside the macrophages continue to multiply for 2 to 8 weeks until the cellular immune response (T-lymphocytes) is effective in stopping the spread of disease by grouping the infection into nodules (granulomas). Mycobacteria may survive inside the granulomas but be held in check from further spread; the granulomas may calcify and be detectable on chest x-rays. This stage of infection usually does not produce symptoms and is termed primary tuberculosis.

The overwhelming majority (90%) of primary tuberculosis cases in the U.S. end at this stage. (95% of the individuals who successfully resolve the primary infection undergo complete healing with no subsequent recurrence.) Progressive primary tuberculosis occurs in the remaining 10% of the infected cases, resulting in a dry cough that at first progresses to a productive cough containing sputum, pus, and sometimes blood. Other symptoms include fatigue, weight loss, anorexia, low-grade fever, and night sweats. Untreated, the pulmonary lesions grow and normal pulmonary architecture is lost, resulting in death in about 60% of the cases with a median course to death of 2.5 years. Sometimes the disease reactivates. Reactivation tuberculosis presents similar symptoms as pulmonary tuberculosis and occurs when the immune system is no longer effective in containing the "walled-off" bacilli.

Prevention of tuberculosis (TB) after some types of exposures may be medically indicated with drugs. A number of live TB vaccines are available and known collectively as BCG. However, the efficacy (ability to produce the desired effect) is in question. Controlled studies in North America and the U.K. indicate that vaccination offered greater than 80% protection, while little or no protection developed in other populations. The vaccine is not routinely used in laboratory personnel. BSL 2 precautions are recommended for preparing acid fast smears, while BSL 3 precautions are recommended for propagation and manipulation of cultures or handling nonhuman primates (because they have a respiratory reflex like humans and can transmit the disease through the aerial mode). BSL 3 adds respirators to the list of potential personal protective equipment, and the 1988 version of "Biosafety in Microbiological and Biomedical Laboratories" has a special precaution that "molded surgical masks or respirators are worn in rooms containing infected animals."

An article by Neville Tompkins in *Occupational Health & Safety*, Vol. 62, May, 1993, reports that although some experts disagree, the National Institute for Occupational Safety and Health (NIOSH) recommended in October, 1992, that high-powered air-purifying respirators be worn by health care workers. Reportedly, other major public health and medical organizations including the CDC, American Lung Association, and Infectious Disease Society of America recommend (in part) that "health care workers and others entering TB isolation rooms should wear particulate respirators which resemble surgical

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masks, but are far more effective in blocking TB bacteria." In October, 1993, the CDC recommended filter characteristics capable of removing particles 1 μ in size at 95% efficiency. The only filters that meet that standard today are HEPA filters that remove particles 0.3 μ in size at 99.97% efficiency. In May, 1994, NIOSH proposed changes in the respirator certification process to test filters for particles of 0.3 μ but at three different efficiencies (99.97, 99, and 95%).

Rabies is an acute viral disease caused by the transmission of infected secretions, usually saliva, from an infected animal licking damaged skin, mucous membrane, or from a bite. Transmission is also known from infected aerosols, and postexposure prophylaxis is always indicated subsequent to a bite where the bat cannot be sacrificed for brain tissue testing (other common reservoirs include skunks, foxes, and raccoons). The virus replicates in muscle tissue near the point of entry and then travels from the wound along nerve pathways to the brain where further replication occurs in the gray matter. The virus then spreads to other tissues and organs via autonomic nerves. Depending on the amount of virus introduced, the host's immune defenses, and the distance the virus must travel to the brain, incubation varies significantly from 10 days to over 1 year (average 4 to 8 weeks). Clinical symptoms include fever, headache, malaise, myalgias (muscular pain), anorexia, nausea, vomiting, sore throat, and an inability to drink water, progressing to marked increase of motor activity, excitation, confusion, hallucinations, combativeness, bizarre aberrations of thought, and increasingly shorter periods of lucid thought until a lapse into coma and finally death by respiratory failure. Once symptoms start, the disease is almost always fatal, with only three well-documented cases of recovery. Postexposure prophylaxis is effective. Follow-up evaluation from over 575 cases of bites from confirmed rabid animals has shown that no person who has received passive (antirabies antiserum) and active immunization (antirabies vaccine) has developed the disease. In the U.S., fewer than five rabies cases are reported each year.

Rocky Mountain spotted fever is caused by a parasitic microorganism (a type of rickettsia) to arthropods (insect and insect-like animals, e.g., lice, fleas, ticks and mites). Like viruses, rickettsiae can only procreate by invading the cells of another life form. Transfer to humans is by the bite of an infected tick or from its feces where the rickettsiae can pass through a break in the skin to access blood. About 1000 cases are reported per year, mostly on the Atlantic seaboard. Symptoms include anorexia, nausea, and sore throat progressing to fever, aching, and headache in 3 to 10 days. Small pink spots appear on the wrists and ankles 2 to 6 days after symptoms begin, then spread over the body, darken, enlarge, and bleed. Treatment with antibiotics usually cures the disease. Untreated cases marked with high fever may result in death from pneumonia or heart failure. Prevention involves using insect repellent in tick-infested areas, examining the body daily, and gently pulling away ticks with forceps when found.

San Joaquin Valley fever is caused by inhalation of a mold that grows in soil; about 60% of infections are subclinical (unrecognized except for a positive coccidioidin skin test). Symptoms may be more severe in other cases requiring medical attention. Fewer that 1% of the cases result in spread of the disease from the chest, or meningeal form, which has significant long-term mortality rates. Prognosis in cases where the disease is limited to the chest is good by providing necessary symptomatic therapy. Limited disease symptoms after 10- to 30-day incubation include influenza-like illness with malaise (vague feeling of illness or depression), fever, backache, headache, and cough.

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Scabies or mites, barely visible as white dots, burrow into the skin where they lay eggs and can be seen on the skin as tiny, gray, scaly swellings, usually between fingers, and on wrists, genitals, and armpits. Infestation causes intense itching, especially at night, and scratching results in scabs and sores. Although infestation is most likely through physical contact (e.g., sexual intercourse), scabies is highly contagious and can pass from one person to another standing close to the infested person. Usually the whole family is treated by applying an insecticide lotion to all skin below the head.

Snakebite may be predominantly neurotoxic (coral snake) causing respiratory paralysis; or predominantly cytolytic (e.g., rattlesnake) causing local pain, redness, swelling, and forcing the flow of blood out of surrounding tissue. Tingling in the mouth, metallic taste, nausea, and vomiting may occur. Emergency treatment includes immobilizing the patient and part bitten in a horizontal position. Avoid manipulation of the area bitten and immediately transport the patient to a medical facility for treatment. Do not give the victim alcohol or stimulants, or apply ice. The trauma to underlying tissue resulting from incision and suction performed by untrained personnel is probably not justified, considering less than 10% of the venom can be recovered.

Spider bites involve toxins causing localized pain, redness, and swelling and is self-limiting. The more venomous black widow spider causes generalized muscular pains, muscle spasms starting at the site and spreading, and rigidity. Symptoms may continue for several days. Death from cardiac arrest or respiratory failure occurs occasionally in children and the elderly, but is uncommon in adults. Treatment for black widow bites is to relieve symptoms with narcotics or muscle relaxants. Antivenom is usually not required but is used for the very young or elderly who do not respond to the previous treatment. There is no proven treatment for the bite of the brown recluse spider. Its bite may lead to the death of local tissue, requiring excision; other treatments are being developed.

Tetanus is caused by spores of a bacteria found in soil and manure (and human intestines); infection produces pain and tingling at the site of inoculation, followed by spastic reaction of nearby muscles. Usually, stiffness of the jaw ("lockjaw") and neck, dysphagia (difficulty swallowing), and irritability follow. Spasms and rigidity of muscles develop in the abdomen, neck, and back. Asphyxia (unconsciousness or death caused by lack of oxygen) may result from spasms in the larynx or chest. Spasms usually subside in 10 to 14 days. The disease is completely preventable by active immunization, beginning with childhood vaccination and obtaining booster doses every 10 years, or at the time of puncture injury (including human bites) if it occurs 5 years after a dose.

Conclusion

Because many of the experts with whom investigators must work do not come from police backgrounds, interpersonal skills are vital. Most experts, including those who routinely or only occasionally work for law enforcement, are eager to help. However, police investigators should remember that they are working with people from a variety of backgrounds. Working with them in a spirit of mutual cooperation and respect and in a professional manner will aid in achieving successful outcomes to investigations.

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5 Processing the Crime Scene

Chapter 3 briefly outlined some of the measures necessary for a proper crime scene search. The purpose of this chapter is to develop these concepts more thoroughly into a plan for processing a crime scene.

Plan of Action

Processing a crime scene, including careful examination, note taking, sketching, photography, and collection of physical evidence, requires a plan of action. The crime scene must be approached in a systematic, methodical way; certain steps must be performed before others. Considerations about legal and scientific matters must be made when searching a crime scene. These details must be included in an action plan or method of approach and practiced when examining the scene of a crime.

The plan of action should be readily available to crime scene investigators. It should be included in a written departmental procedure to define crime scene responsibilities, and may also detail what tasks are to be done and in what order. It is, of course, impossible to anticipate every detail in a crime scene investigation; however, certain ground rules should be set forth to direct uniformed personnel, detectives, and crime scene investigators to a specific goal.

Note Taking

Of all the duties and responsibilities of an officer conducting the crime scene search, perhaps the most important is note taking. Note taking is important for several reasons. It forces investigators to commit observations to writing and to keep a detailed record of everything observed and accomplished. Frequently, a seemingly insignificant item found in an investigator's notebook turns out to be critical to an investigation.

Some general points about notes and note taking are:

1. Notes should be made as events unfold, and in chronological order.
2. Notes should detail, step-by-step, all actions.
3. Notes should be complete and thorough.

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4. Notes should be clearly and legibly written. Sloppy notes or those that do not clearly state the investigator's meaning will be subject to misinterpretation.
5. Negative or unexpected conditions (the absence of bloodstains or a light that is found on) should be noted.
6. The note taker should be as specific as possible. If an item of evidence is to be located, a description such as "on the living room floor, 6 inches east of the west wall and 3 feet south of the north wall" should be used. Vague statements such as "near" or "to the left of" should be avoided.
7. Case notes, sketches, tape recordings, or photographic negatives should never be discarded. They should be placed into a case folder and retained for as long as the department's policy indicates.

The investigating officer or detective is responsible for the entire investigation, including the crime scene. Upon arrival at the scene, the detective should obtain a brief statement from the first officer at the scene, detailing what transpired. The investigating officer should gather much information, and many facts and opinions, from the first officers. The investigating officer's first contact with the scene will be a cursory one. Care should be taken not to disturb anything. Evidence should not be moved or touched. Evidence will be properly documented, measured, sketched, photographed, and fingerprinted later. At the start of the process, the investigator will begin to digest information reported by first officers, witnesses, victims, and suspects, together with the overall appearance of the crime scene. These details are used to formulate a plan to process the crime scene.

Protecting the crime scene is an ongoing concern. Uniformed officers should remain posted at the scene. The victim's family, the public, and the press should be kept away from the crime scene. Fellow officers, especially command officers, who have no business visiting the crime scene are a more serious problem. In highly publicized crimes, superior officers often exhibit a desire to view the scene. This should be avoided; one suggestion is to set up a command post with a pot of coffee to help keep unnecessary persons away. Another possibility to discourage officers who visit a scene is to give them an assignment and require them to file a written report or, at the minimum, have them sign a log. Sometimes it may be necessary for the investigator in charge of the crime scene to inform the superiors politely that the scene is still active and their presence might compromise findings and interfere with collecting physical evidence.

Tape recorders make it easy to take down information that can be transcribed later; some investigators use pocket microcassette tape recorders for note taking. Investigators should remember that impromptu remarks from other officers at the scene might later prove embarrassing. Videotaping creates similar problems.

Notes taken at crime scenes should include the following information:

- Date and time the crime was first reported to the police
- Type of crime
- Location of the crime scene and a description of the area
- Description of the crime or event leading up to the investigation
- Name of the person who requested the crime scene investigation
- Names of all officers, witnesses, investigators, and specialized personnel at the crime scene

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- Names of the persons who conducted the crime scene search and who took photographs and fingerprints, made sketches, and collected evidence
- Weather and lighting conditions at the time of the investigation
- Description of the primary crime scene, including the location of the body and accompanying details
- Location of any evidence found during the investigation and the names of those who collected it, and the results of a search for fingerprints and other trace evidence
- Description of the location, including the surrounding houses, streets, and community
- Description of the interior and exterior of the crime scene, including the type of residence, number of rooms, and windows
- Description of the outside of the scene including the terrain, type of plants, soil, etc.
- The date and time the crime scene investigation was concluded

These details represent only some of the many pieces of information that should be included in the investigator's notes; they do not represent all the possible information. Officers should use this list as a guide. Meticulous note taking is one of the keys to good police work and competent crime scene investigation.

Crime Scene Search

Once the investigator has gathered as much information as possible and made a survey of the location, the actual crime scene search may begin. Processing a crime scene consists of:

1. Surveying the crime scene
2. Photographing and sketching the crime scene
3. Mapping and measuring the crime scene
4. Recording and documenting the location of physical evidence at the crime scene
5. Searching for fingerprints and other physical evidence

As a simple, general rule, the most fleeting, fragile evidence should be collected first. Thus, taking photographs and making crime scene sketches take priority because crime scenes change with the passage of time and the investigator's objective is to make a record of the scene that reflects as closely as possible its original condition.

A systematic search of the crime scene should be conducted. Criminal investigation texts recommend a variety of search patterns: the strip or lane search, grid search, spiral search, and quadrant search. Some search patterns lend themselves to outdoor areas, while others are more appropriate to indoor crime scenes. The important idea to remember is that thoroughness is the goal of the search plan[1] (Figure 5.1).

Indoor crime scene searches are best done with two persons. One easy way of accomplishing a search in a room is to divide it in half. Each investigator searches one half. After they have done a thorough search, they switch halves.

[1] Whatever the search procedure, the "mill around" method is never correct. In this method, using a pen or pencil (for indoor crime scenes) or a stick (for outdoor ones), the officer randomly pokes around, pushing aside objects and picking up items that look interesting. This is never a proper way to conduct a search!

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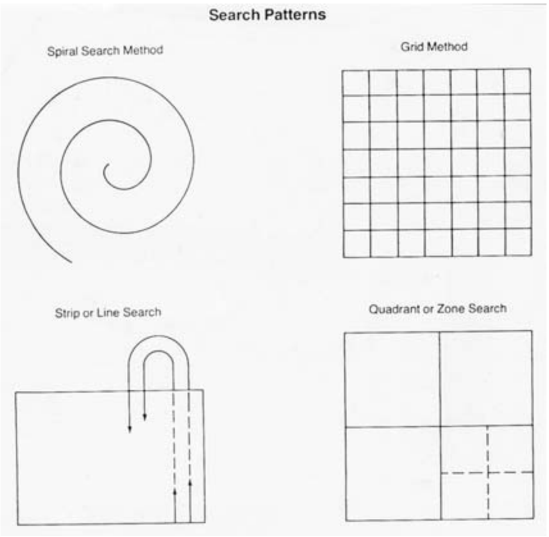

Figure 5.1 A workable pattern for conducting a crime scene search should be formulated and used. Several typical patterns are shown here. The specific case will dictate which search pattern is used.

Outdoor searches often cover greater areas than indoor ones and more searchers may be required. Again, a systematic method should be used. The area can be roped off into grids, each square representing a given search area. A 6- × 6-foot area is a reasonable size for a detailed and comprehensive search. As in the indoor search, each area should be double-checked for thoroughness.

Do not forget to look up! Generally, investigators concentrate on what is on the ground and at eye level when searching a crime scene. However, evidence may be above their heads, on ceilings, or caught in tree branches.

Before walking onto tile floors, crime scene investigators should consider that shoe prints might be present in dust or dirt. Even if others have already walked on the floor, it is worth a try to look for prints. A simple technique is to use a flashlight shined at a low or oblique angle to the floor in a darkened room to look for dust prints. If any are present, they can be photographed with a camera on a tripod using flash side lighting. After photographs are taken, the print can be lifted using an electrostatic dust print lifter or a large rubber-backed lifter. Both items are commercially available from police supply companies.

Nighttime outdoor crime scene searches present difficult problems. If possible, any search should be put off until daylight hours. If waiting is not possible, high-intensity lighting and portable generators may provide sufficient light. Fire departments generally have such gear.

Vehicle searches demand the same degree of care. The nature of the crime determines the area of the car to be searched. In hit-and-run cases, the exterior and undercarriage are important; the interior is examined more carefully in a rape or murder case. In most cases, examinations begin with an examination of the exterior portions of the vehicle. In a hit-and-run incident, the examination focuses on areas that struck the victim: bumper, grill, windshield, and undercarriage. Look for the presence of dents, broken headlamps, damaged paint, and fabric impressions. Blood, hair, torn pieces of clothing, or fibers may be

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present. Broken and missing parts of the vehicle should be thoroughly documented. A hydraulic lift can be used to lift the car to examine the undercarriage for evidence. All evidence should be photographed and sketched. Fingerprints may be found on door handles, outside mirrors, or the area above the driver's-side exterior door panel where some drivers rest their left hands.

The interior of the vehicle should be searched for fingerprints. A systematic approach should be taken, such as dividing the interior into sections: front right, front left, and back right, back left. Before entering the vehicle, an examination for trace evidence should be made. If anything of value is noted or suspected, it should be collected before entering the car. Trace evidence such as hairs and fibers can be collected using forceps or tape lifts. Vacuum cleaners can be used; however, vacuums pick up much debris, which causes considerable extra work for laboratory examiners. Considering the possibility of finding trace evidence will cause the investigator to avoid contaminating the interior of the vehicle with foreign material that may be carried inside by the examiner. Fingerprints should be searched for after trace evidence is collected (Figure 5.3).

Crime Scene Photography

The well-worn saying "one picture is worth a thousand words" certainly holds true with crime scene photography. No matter how well an investigator can verbally describe a crime scene, photographs can tell the same story better and more easily. The following is not intended to make the reader an expert in photography, but merely to discuss certain issues that relate to photography in general and crime scene photography in particular.

Before a detailed examination of the crime scene is made or before any items are moved or even touched, the crime scene should be photographed. The photographs should be taken to clearly and accurately depict the scene as it was found, the paths taken by the criminal to the scene, the point of entry, the exit, and the escape route. Detailed photographs should be taken to show items of physical evidence in the condition in which they were found by the investigator prior to their removal.

Types of Cameras

Many types of cameras are available for use in crime scene photography. Larger format cameras, such as a 4 × 5 or 120 were the trend in past years, favored because they produced a larger negative that resulted in more clarity when enlarging photographs. If two identical scenes are photographed with a 4 × 5 camera and a 35-mm camera with the same type of film and enlargements are made from each, the photograph taken with the larger format camera offers greater resolution, and very small objects will be easier to pick out.

Not withstanding the benefits of the large-format camera, 35-mm cameras have become the norm. The 35-mm single-lens reflex camera offers the greatest versatility. Many police departments choose this camera for routine crime scene work when issues such as cost of film and camera and ease of use are considered.

So-called "point and shoot" cameras are useful in a variety of instances. They are inexpensive, take acceptable pictures, and are useful for officers who do not have much training in photography. The cost of these cameras and the even more inexpensive "disposable" cameras makes it possible for every police vehicle to carry a camera for use as needed.

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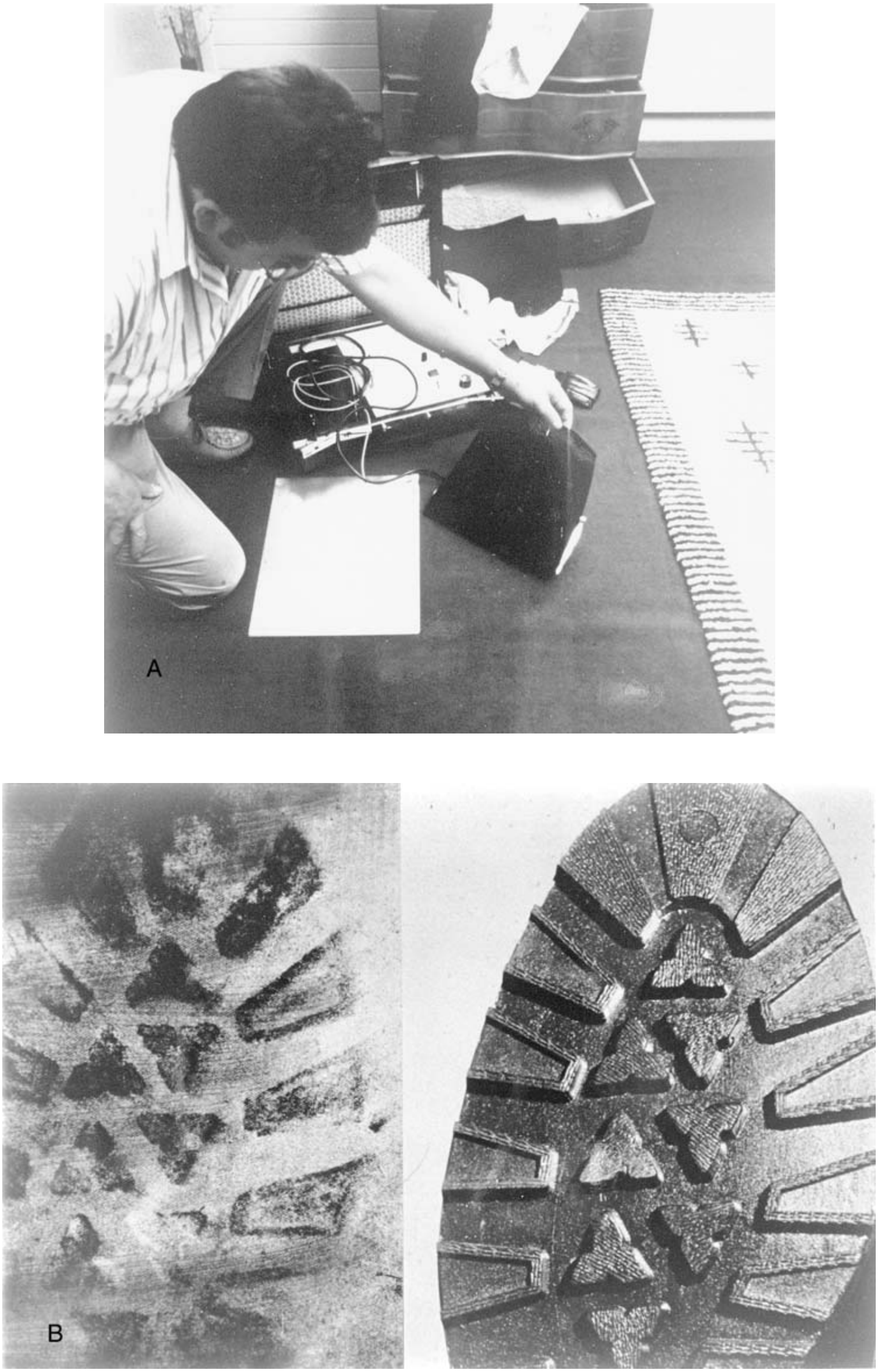

Figure 5.2 (A) Crime scene investigator lifting a foil film to collect a footprint using static electricity. (B) The lift is shown next to a photograph of the shoe's sole. *(Zurich Cantonal Police Forensic Science Laboratory.)*

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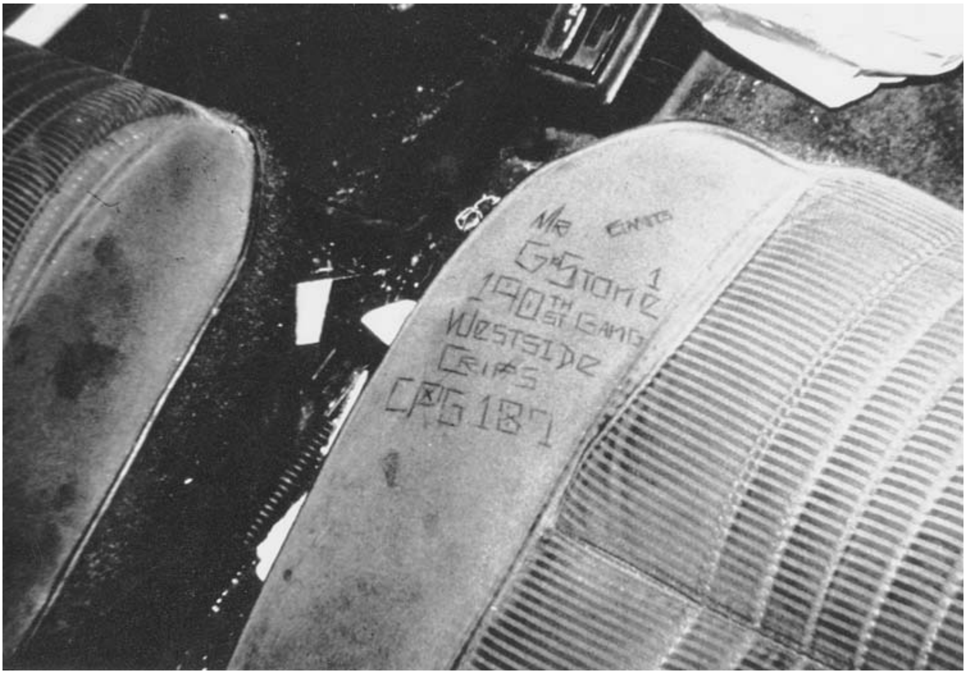

Figure 5.3 The vinyl seat of a car with distinctive gang-style writing (the "187" refers to the California Penal Code section for murder). *(Los Angeles County Sheriff's Department.)*

Polaroid® cameras are useful for identification photographs. If a photograph of a deceased person is needed to identify him, a Polaroid photograph works well. The quality of the photos is acceptable. However, cost is a consideration. Police agencies may wish to limit the number of Polaroid cameras available for field use because film costs can mount rapidly.

Digital cameras represent the latest technology and deserve consideration. During the last few years prices have fallen and quality has improved, making digital photography a cost-effective choice. Instead of film, photographic images are stored on magnetic devices. The diskettes can be placed into a computer and viewed on the screen and printed out using a specialized printer. Pictures can also be incorporated into a report.

The cost of digital cameras is at the point at which they are comparable to 35-mm cameras and have near-comparable resolution. Digital photography is a rapidly evolving technology that will see greater use and ultimately eclipse traditional photography.

Types of Media

Numerous types of film are available today. Color negative film has become standard in many police departments. Print film speeds are available as high as ASA 1600 for color and ASA 3200 for black and white (which can actually be pushed to an ASA of 5000). Color photography offers good color rendition and presents few problems in indoor or outdoor crime scenes. Black and white film should not be dismissed. It is less expensive than color film and offers excellent resolution and very high speed when needed in very low light and near-dark situations.

For digital cameras, the photographic resolution is measured in pixels. Camera prices increase with increased resolution. For crime scene photography, a digital camera with a

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resolution of 4 megapixels is the lowest resolution one should consider. A 4-megapixel camera will yield a reasonably clear 8 × 10 inch photograph; however, for photos requiring greater resolution, traditional film cameras are preferred.

Number of Photographs

How many photographs should be taken? There is no simple answer, but as a general rule, it is better to overshoot a crime scene (take more photographs than are necessary) than to economize and take too few. Time, however, may be a concern. Certain types of evidence need to be collected quickly. In the final analysis, the experience of the crime scene photographer can best answer the question of the number of photos to take.

Photographs serve a number of purposes. They aid in refreshing the memories of witnesses and investigators and show the relationships of items of evidence at the crime scene. A very important purpose of crime scene photographs is that they help to convey an image of the crime scene and the circumstances of the crime to the jury. With these purposes in mind, a number of important photographs should be made in almost every crime scene, including (Figure 5.4):

- **Location**. Photographs of the location of the crime scene should be made. In the case of a residence, for example, the exterior of the dwelling should be shot, including the locations of doors and windows. Photographs of surrounding areas of the house should be included, such as the front and backyards and views in each direction. Aerial photographs are often useful to depict the location of the principal site and other areas of interest in proximity to the crime scene.
- **Witness photographs**. Witness photographs are overall photos of the crime scene. They depict the scene as observed by a witness. In the case of a murder crime scene in a house, such photographs might depict the victim lying on the floor as viewed from a number of locations in the room. These photographs are designed to tell a story, to relate what the location looked like to someone who was not present. To accomplish this task, several overlapping photographs should be made. In addition, long- and intermediate-range photographs should be taken to show perspective and the relative positions of different items found at the crime scene.
- **Close-up photographs**. In addition to long- and intermediate-range photos, close-up pictures should also be taken to further clarify the scene. Two photographs should be routinely taken: (1) one showing the item as it actually appears and (2) a photograph of the same item with a ruler included. It is important that the film plane be parallel to the plane of the object. The ruler and the parallel film plane ensure the ability later to produce good-quality enlargements or 1:1 photographs of the evidence.
- **Evidence photographs**. Photographs of all items of evidence should be made prior to their removal or changing the location or position of items in any way. Photographs should be made of shoe imprints, fingerprints, bloodstains, weapons, defense wounds, and other such items. Additional photographs should be taken during the crime scene search as new items of evidence are discovered when items at the crime scene are moved.

When taking photographs, a photo log is recommended. Some police agencies use preprinted forms and others keep track of photographs by some other means. A typical

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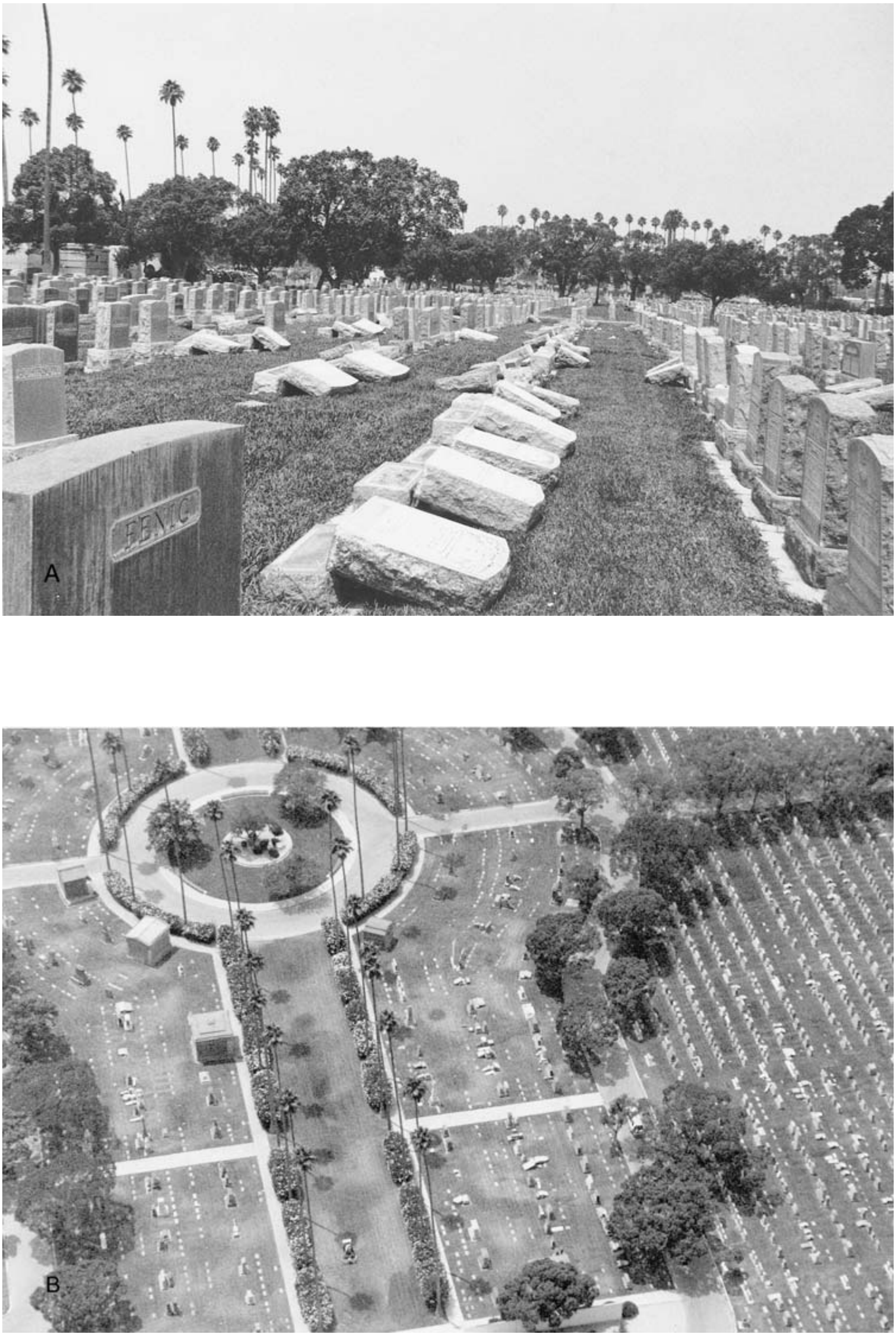

Figure 5.4 Photographs of a crime scene serve to depict its nature and extent. Photograph (A) is a view from one perspective; the aerial view (B) provides a picture of the total scene. *(Los Angeles County Sheriff's Department.)*

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Figure 5.5 A bearded victim was shot in the face with a shotgun. A small fragment of beard hair and skin spattered back onto the suspect's corduroy coat. *(Los Angeles County Sheriff's Department.)*

log might include the case number, date, time, photographer's name, type of camera, lens, film, and a listing of each photograph. The list may include the shutter speed, f-stop, and a very brief description of the location of the evidence. An alternative to a photo log is using a camera back that automatically places the date onto the photograph. Normally, photographs should be taken at eye level to give the proper perspective of the scene. If the photo is taken from a different perspective, it should be noted in the log.

The type of lens used also affects the perspective of the scene. A normal lens should be used, such as a 50-mm lens in the 35-mm format. If the crime scene is indoors with cramped quarters, medium-wide-angle lenses may be used; however, the lens change should be noted in the photo log.

In low-light situations, flash photography is recommended even though high-speed film may handle these situations. Most shooting is done with a hand-held camera, but for exposures less than 1/60th of a second, a tripod should be used to ensure sharp photographs.

Photographs accurately represent the crime scene as seen by the witness or investigator. They should be clear and sharp. Extraneous subjects and items at the scene do not belong in the photographs; crime scene equipment and personnel should not be present in photographs.

Posed photographs that locate where a witness stood when first entering the crime scene may be taken. A photograph should then be taken from that location to show the appearance of the crime scene from that point of observation.

This section is not meant to be an all-encompassing guide to crime scene photography, but rather to present some important points to consider. Several worthwhile classes in general photography that give the beginning crime scene photographer the basics on the

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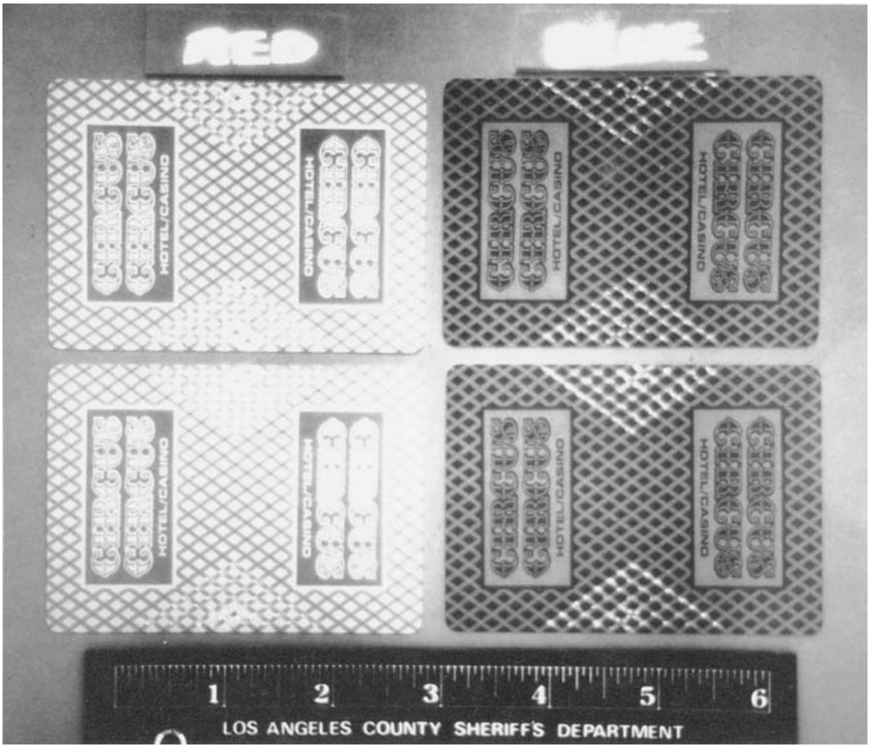

Figure 5.6 These playing cards (left) look perfectly normal under ordinary room light. They are, however, obviously marked (right), as shown when viewed and photographed under reflective infrared lighting. *(Los Angeles County Sheriff's Department.)*

subject of photography are offered in colleges and adult education programs. The *Kodak Master Film Guide*, available in most photography shops, is a valuable pocket reference that can be carried in a field kit for ready information. Nikon offers a good photography school on basic 35-mm photography at locations around the country; this is an excellent program for individuals reasonably familiar with general photography who wish to improve their capabilities. Universities and junior colleges with police science programs may offer classes on crime scene photography. Professional organizations like the International Association for Identification have presentations on crime scene photography from time to time at annual seminars.

Admissibility of Photographs

For a photograph to be admissible in court, the investigator must be able to testify that it accurately depicts the area shown. To be accurate, it must represent the subject matter properly in terms of color, scale, and form. Photographs must be in focus and should show the relationships and distances between objects. Crime scene sketches (discussed later) also assist in depicting the crime scene.

All negatives from the crime scene photographs should be retained. They are important to demonstrate that the picture has not been altered. Negatives are also important if enlargements of certain areas of the crime scene are needed to better depict parts of a photograph.

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To reiterate the importance of scales or rulers in photographs: they are essential to show the actual size of the object in question. Some courts may not allow even minor modifications of photographs; in those cases, it may be necessary to take duplicate photographs to show the scene (1) as it was and (2) with the scale.

Videotape

Another method of recording the crime scene is videotape. Lightweight, portable, low-light video cameras are ideally suited for gathering a video rendition of a crime scene. Videography does not do away with the need for still crime-scene photographs, but has the advantage of more graphically depicting the scene.

When videotaping a scene, the investigator should walk the video operator through the location. The filming should begin outside an indoor crime scene or with an overall pan of the outdoor location. The detective should narrate the videotape by recording the audio portion as the videotape is shot. The narration should include the name of the speaker, time, date, location, case number, and other pertinent identifying information.

If videotapes are to be used as evidence, they should not be edited or erased. The entire tape must be in its original condition if it is to be admissible as evidence. Some agencies use edited videos solely to refresh the investigator's memory. Courts may or may not admit these tapes for the jury's consideration. As with most generalizations on the legal aspects of crime scenes, it is prudent to check with local authorities to determine what will be acceptable to the prosecution and to the court. It is better to find out in advance rather than to assume the practice is acceptable and then find out that a key piece of evidence is excluded for some legal reason not considered by the investigator.

While the scene is being recorded, other personnel at the location should be silent because their voices can be picked up. Such conversations may prove distracting and sometimes embarrassing if recorded.

As with photographs, close-up videotape recordings of small items of evidence should contain a scale to show the actual size of the item. Additionally, panning the area and zooming in on the item should show the relative location.

Sketching the Crime Scene

Photographs alone are not sufficient for recording a crime scene adequately. A crime scene sketch should also be routinely made. Sketches and photographs complement each other to depict the crime scene adequately and properly. Sketches clarify the appearance of the crime scene and make it easier to comprehend. It is, therefore, important for investigators to develop the ability to make good crime scene sketches.

A crime scene sketch is not considered an architectural drawing, such as one drawn by an artist or forensic surveyor. It is simply an illustrative diagram or drawing that accurately depicts the appearance of the crime scene. Nevertheless, sketching the crime scene requires some skill on the part of the investigator. Generally, it is easier if two people work on the sketch: one person to draw and the other to take measurements.

Sketches sometimes leave out important information or contain errors. Yet despite these drawbacks to and problems in making crime scene sketches, they do provide important information and, when done properly, are very helpful. Sketches help investigators

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recall details of the crime scene. They also aid prosecutors, courts, and juries to better understand the crime scene.

Sketches offer a permanent record of the relationship of items at the scene to each other and help to supplement photographs. They depict the overall layout of the location more easily than can be accomplished by photographs. Sketches also allow for selectivity. A sketch may be drawn purposely to leave out extraneous or confusing details that would be recorded in a photograph.

Crime scene sketches can provide a record of conditions that are not readily recorded by other means. Distances can be shown over large areas and topography can be easily illustrated. Paths taken by subjects or vehicles can be demonstrated on drawings more easily than on photographs. Drawings may be used to aid in questioning suspects and witnesses of crimes and to authenticate testimony of witnesses. Sketches combine the best features of photographs and crime scene notes.

Information Included in Crime Scene Sketches

What information should be present on a sketch? Information placed on a sketch is used to make the drawing understandable and admissible into evidence. Like all evidence, it should contain case-identifying information: case number, name of suspect, victim, and investigator, person drawing the diagram, and date and time the sketch was made. It should contain a scale, if required, and distance measurements between items present on the sketch. The location depicted in the drawing should be included as well as reference points to located items. A legend or key may be helpful to identify and clarify portions of the drawing.

Equipment

Writing materials are, of course, required. Although pens may be used, lead pencils are easier to work with, especially if erasures are made. Colored pencils are also useful to outline important items. Graph paper is best to use, although blank paper will do. Graph paper simplifies scale drawings and provides guidelines for line measurements. Some sort of drawing surface, such as a clipboard, is helpful.

Measuring devices such as rulers and tapes are required. A 50- or 100-foot surveyor's tape is especially useful to measure longer distances. A folding 6-foot carpenter's ruler is also a useful piece of measuring equipment. Inexpensive, infrared-measuring devices used by realtors and contractors make measuring interiors very easy. Finally, a compass is useful to determine the direction.

Types of Sketches

Different types of indoor and outdoor crime scene locations present different problems in sketching. To best represent the crime scene, it may be necessary to rely upon different types of sketches. The type of sketch chosen by an investigator is not especially important. What is important is that the resulting drawing best depicts the crime scene and most easily illustrates the event to the viewer.

The overview, floor plan, or bird's-eye-view sketch is the simplest and most common one used in diagramming crime scenes. It may be used in nearly all crime scene situations where the items of interest are located in one plane. In addition to its simplicity, it is also the easiest for laypeople, such as jury members, to grasp.

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Another type of crime scene sketch is the elevation drawing. This type of sketch is used when the vertical, rather than the horizontal, plane is of interest. Thus, if bloodstains were present on a wall of a house, the elevation drawing of the wall would be used to depict this scene.

The cross-projection, or exploded, view is a combination of the preceding two types. It is similar to the floor plan sketch except the walls have been folded down into the same plane as the floor.

The perspective drawing is another type of sketch that depicts a three-dimensional drawing of the scene. Although the final drawing will be very clear if done properly, this type of sketch requires considerable artistic skill and, therefore, is generally not recommended.

Locating Objects in the Sketch

Once the drawing has been made and the relative locations of the items have been sketched in, it is necessary to locate them in the sketch. Location is defined as the actual position where the object is located in the crime scene. A position on a plane or flat surface is defined by two measurements. A knife located on the floor of a room requires two measurements from two fixed points to locate its position on the floor accurately. A measurement to show location could be taken from the north wall and the east wall, e.g., 3 feet from the north wall and 6 feet 7 inches from the east wall.

Although perpendicular measurements are the easiest to use, they may be impossible in outdoor crime scenes. In those situations it is necessary to find fixed points to locate the item in question. This can be done by using telephone poles, fire hydrants, trees, the exterior corner of a building, and so on. Whatever the item of reference used, it must be permanent and identifiable. The number on a telephone pole, a street address, or a roadside marker may be used as a point of reference to locate an object.

GPS, or geopositional satellite devices, are used in a variety of industries and, as costs decrease, are likely to become useful locating the position of evidence in remote outdoor crime scenes.

Computer Programs

Commercial computer software is available to render drawings of crime scenes in two- and three-dimensional views. In addition to the ability to draw crime scenes to scale, computer programs have been used to depict trajectories in shooting scenes and to help reconstruct crime scenes. Some of the programs are able to depict the scene in three dimensions on a video monitor and take a viewer through the scene by means of computer graphics. In the courtroom, these systems have been used to project the video image onto a screen and explain to a jury the sequence of events in a crime scene. Software can be used to depict the crime scene in pictorial form as seen from the perspective of the victim or the suspect (Figure 5.7).

Admissibility of Sketches

As with photographs, the sketch may be entered into evidence only by someone competent to testify about its authenticity. The qualified individual must be able to testify that the sketch is a true and accurate representation of the original scene.

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Crime scene diagrams are extremely useful in court presentations. In major crime cases the original crime scene sketch is used frequently as the basis for a finished drawing made by an artist or by using a computer program. In some instances where the scene is particularly complex, an architectural model may prove useful to detail the crime scene.

Collection of Evidence

Following the initial crime scene search, photography, and sketching of the crime scene, physical evidence may be collected. It is useful to set priorities of which evidence to collect first. The most fragile evidence, such as fingerprints, should have first priority. After fingerprints, other fragile evidence such as blood and trace evidence is collected. Once this has been accomplished, the scene should be searched a second time to make certain that potential evidence was not overlooked.

Evidence that is to be sent to the crime laboratory should be packaged to prevent breakage, spoilage, or contamination that will destroy its value. Evidence containers should be sealed and be strong enough so that they will not break in transit.

When evidence consists of several objects, they should be packaged in separate containers or wrapped individually. Each package should be clearly marked as to its contents and then packed in a shipping container. Sometimes, it is necessary to fix articles to the shipping container separately so that they will not come in contact with each other. Bottles and glass containers containing liquid should not be packaged with other evidence because they may break and contaminate the other exhibits. If Styrofoam or other packing material is used for cushioning, any objects that might be altered by contact with such packing material should be separated and tightly wrapped.

Even if objects have been individually identified, they should also be marked with the recovering officer's initials and the date collected so that the identity of a given object cannot be questioned. Identification markings may be placed directly on the object or on a tag attached directly to the object. When this is not practical, markings are placed onto the sealed container housing the evidence.

A transmittal letter with a complete inventory of all items submitted and a request for laboratory examinations should be included with each shipment. The inventory enables lab personnel to check the contents so that small objects among the many items are not misplaced or overlooked. The request for specific examinations allows the forensic science laboratory to determine what needs to be done.

The written request to the laboratory about the case should be as complete as possible, listing sequence of events, statements of the suspect, the victim, witnesses, etc. This information assists the examiner's evaluation of which laboratory tests are required. The information may also provide answers to questions that come up as a result of the laboratory's findings or provide confirmation of findings that necessarily went beyond those specifically requested. It may be helpful to include copies of pertinent police reports or interrogations.

The following is a brief description of packaging instructions for certain items of evidence:

- Objects with fingerprints or glove prints should be packed so that they do not come in contact with each other or the package sides.

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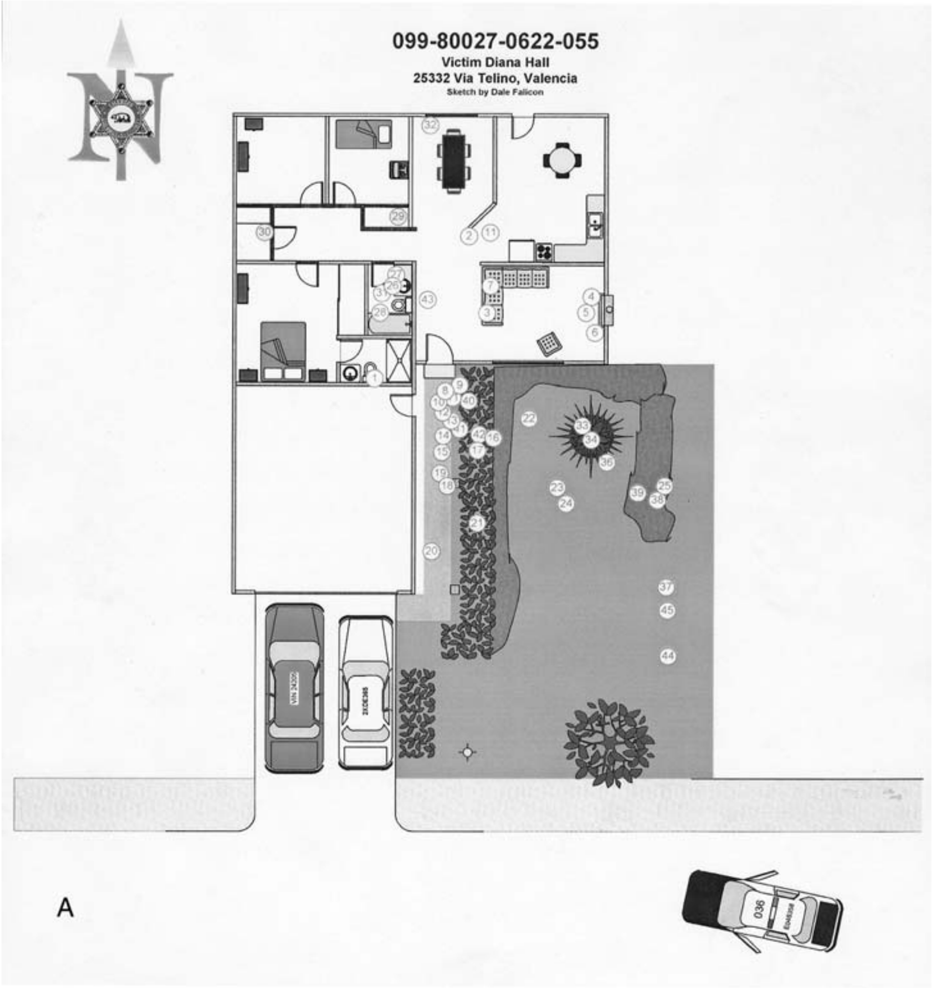

Figure 5.7 (A color version of part A of this figure follows page 256.) Indoor (A) and outdoor (B) crime scene diagrams using a computer-aided design (CAD) software program. The outdoor scene also has a digital photograph imported into the drawing. *(Los Angeles County Sheriff's Department.)*

- Tool marks on objects should be protected from contamination and moisture. Marks may be protected from rust by a light film of oil if transfer of trace material is not indicated.
- Clothing containing dry biological stains (blood, semen, or saliva) should be wrapped separately and in such a way that the stains are not broken or rubbed off. The stained part of the garment may be attached to a piece of cardboard that is then fixed to the bottom of a cardboard container. If several garments are submitted, they may be fixed separately in compartments built inside the container.
- The victim's clothing must not be packaged or come in contact with the suspect's.
- Strands of hair on garments should not be allowed to come in contact with other garments that may contain hair.
- Firearms should be rigidly fixed inside a container without further wrapping. Postal regulations should be consulted before mailing firearms.

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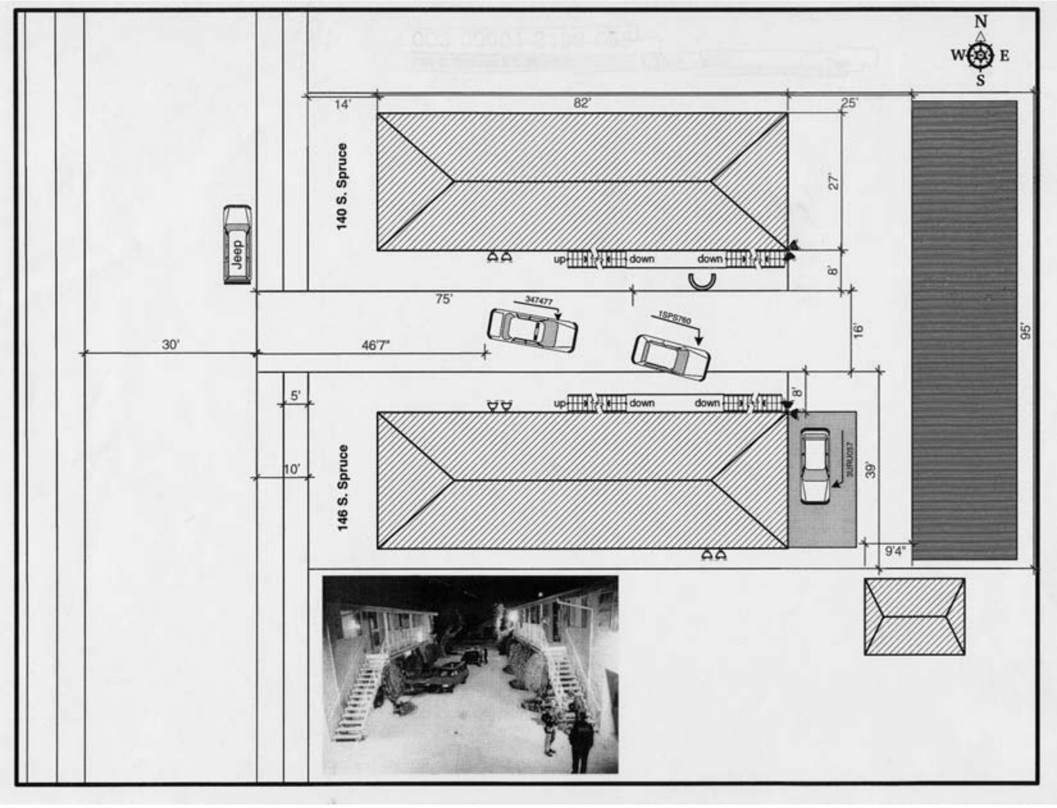

(B)

Figure 5.7 (continued)

- Cartridge cases and bullets should be packed separately with soft cushioning material. Federal regulations should be consulted before shipping.
- Live cartridges and explosives should be packed in cushioning material to protect fingerprints and shipped by a parcel carrier.
- Stomach contents and organs for toxicological examination should be placed in tightly sealed glass jars and packed in cushioning material. The containers should be of a size proportionate to the amount of fluid so that volatile agents do not evaporate.
- Controlled substances should be tightly cushioned in vials or pillboxes so that they will not break. Absorbent cotton should be used.
- Charred paper should be packed in sturdy boxes and supported on all sides with absorbent cotton. The container should preferably not be shipped, but hand-carried to the laboratory. It is also possible to place the charred paper in a large plastic bag that is inflated and sealed tightly.

Proper packaging of evidence cannot be overemphasized.

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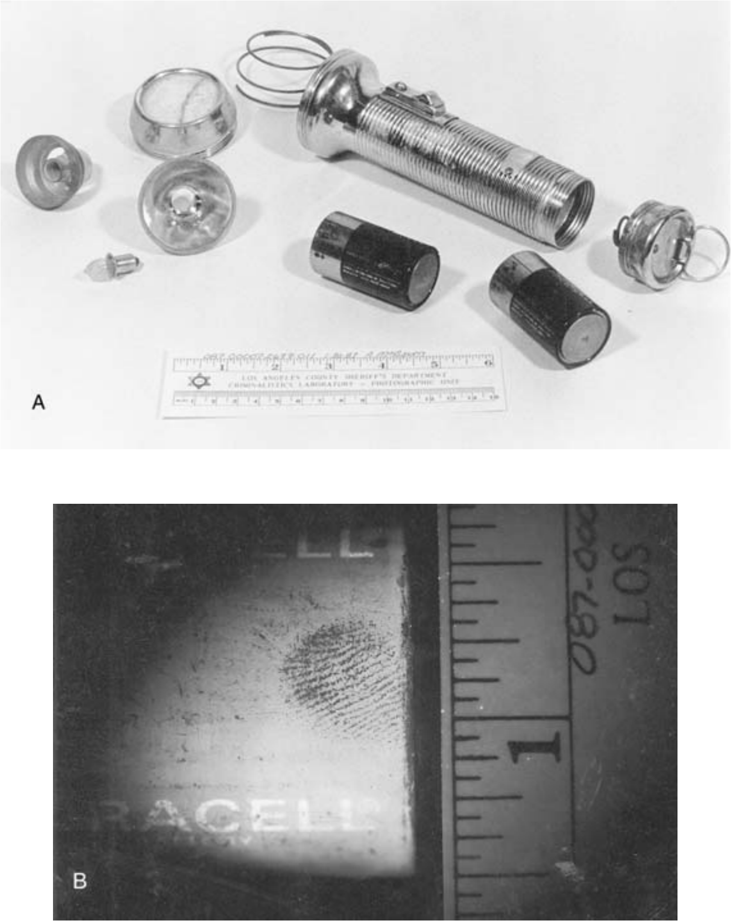

Figure 5.8 Occasionally, a criminal leaves behind an item that at first glance may not seem important to the case. This flashlight (A) was left at a murder scene. Fingerprints developed on one of the batteries (B) led to the arrest of a suspect in the case. *(Los Angeles County Sheriff's Department.)*

Figure 5.9 Commercially available evidence boxes for a rifle, pistol, and knife make collecting such items simple. The boxes also help to preserve items of trace evidence adhering to the larger items. *(EVI-PAQ, http://www.evipaq.com.)*

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6 Establishing Identity

One of the most important purposes of physical evidence is to establish the identity of the suspect or victim. This identification is possible through a variety of methods discussed in this chapter. Fingerprints are usually thought of first when considering methods of identifying individuals.[1] However, techniques such as handwriting examination, forensic anthropology, and forensic odontology are also important and will be discussed.

Fingerprints and Palm Prints

Some of the most valuable clues at the crime scene are finger and palm prints (bare footprints are sometimes discovered and may also identify a person, provided there are known exemplars). Prints are conclusive evidence. An expert's report may state three possible findings:

- The subject made the print.
- The subject could not have made the print.
- The print had insufficient detail to be evaluated.

The value of fingerprints is greatly enhanced by the possibility of identifying a criminal through searching a single fingerprint file or AFIS, an automated fingerprint identification system.

In this section, the term "fingerprints" includes all types of prints of friction ridge skin. Prints of the palms or soles of the foot are made under the same conditions as fingerprints and are preserved in the same manner. It is sometimes difficult to decide whether a print has been left by a finger, the palm, or the sole of a foot. For this reason, in ordinary speech, the term fingerprint has come to include prints of the palms or feet also.

How Do Fingerprints Occur?

When criminals work, they cannot avoid leaving clues in the form of fingerprints unless they wear gloves or some other form of protection. Prints are formed by friction ridges,

[1] Forensic science professional organizations play an important role for practitioners who need to stay current in new technologies. The premier association dealing with forensic identification, e.g., fingerprints, is the International Association for Identification. Anyone seriously engaged in the field of forensic identification should consider membership in the IAI as well as state divisions of the IAI.

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which deposit grease and perspiration on the object touched, and may be produced when criminals take hold of an object or support themselves with their hands. Prints may be formed when fingers are contaminated with foreign material, such as dirt, blood, or grease, or when the fingers are pressed against a plastic material and produce a negative impression of the pattern of the friction ridges.

Where to Look for Fingerprints

In burglary investigations, the perpetrator's point of entry should be the place at which to start a search for prints. It may be possible at that point to determine if the burglar worked with gloves or uncovered hands. If a door was broken open, prints (including shoe prints) may be located on the lock, the immediate surroundings, or other places on the door where the entry had been forced. With broken windows, particular attention should be given to search for pieces of broken glass, which are useful for standards and may contain prints or blood. The common method to break a window is to knock a small hole in a windowpane. A burglar can then break away pieces of glass with his fingers until he has succeeded in making an opening large enough to be able to reach the window latch. Often, fingerprints or glove prints are found on broken pieces of glass. Broken glass does not always lie just inside the window because burglars sometimes dispose of the broken glass shards to conceal the entry. Fingerprints may be left on the inside of the windowsill, the window frame, and jamb when the burglar climbs through the window and grips these parts of the window frame.

Searches for fingerprints should be made in areas where the burglar is suspected to have eaten or had a drink. Prints on glass or china are generally of good quality. If the criminal became drunk at the scene, productive results can be expected from the print search. In some cases the burglar wore gloves at the start, began drinking alcohol, and gradually became intoxicated. Forgetting caution, the gloves were removed. If the burglar removed liquor bottles from the scene, prints may be found on glasses or china or on bottles that were moved and examined by the thief.

Light switches, circuit breakers, and fuses should always be examined, as well as any light bulbs that were loosened or removed. If the criminal wore gloves, special care should be taken at places where the activity was of a type in which gloves would have been a hindrance. For example, opening a case or drawers with difficult locks or searching in the drawers of a bureau may be difficult with gloves. Burglars will remove gloves during the crime and leave fingerprints at the scene. If the thief used the toilet, he might have removed his gloves. Prints should be searched for on the toilet-flush lever, on the door lock, and on any paper that may have been used.

Burglars sometimes bring tools or other objects to the scene and leave them behind. Fingerprints may be detected on papers used to wrap tools, on flashlights (do not forget to examine the batteries), and other items such as the inside of latex gloves. All smooth surfaces on which prints could have been left should be examined. Good prints are often found on glass, china, polished, painted, or otherwise smooth surfaces, smooth cardboard cartons and paper. In some cases, prints have been recovered on rough surfaces, starched collars, cuffs, and newspapers. When examining furniture, do not omit places the criminal may have touched when pulling out drawers or moving the furniture. Even if the thief

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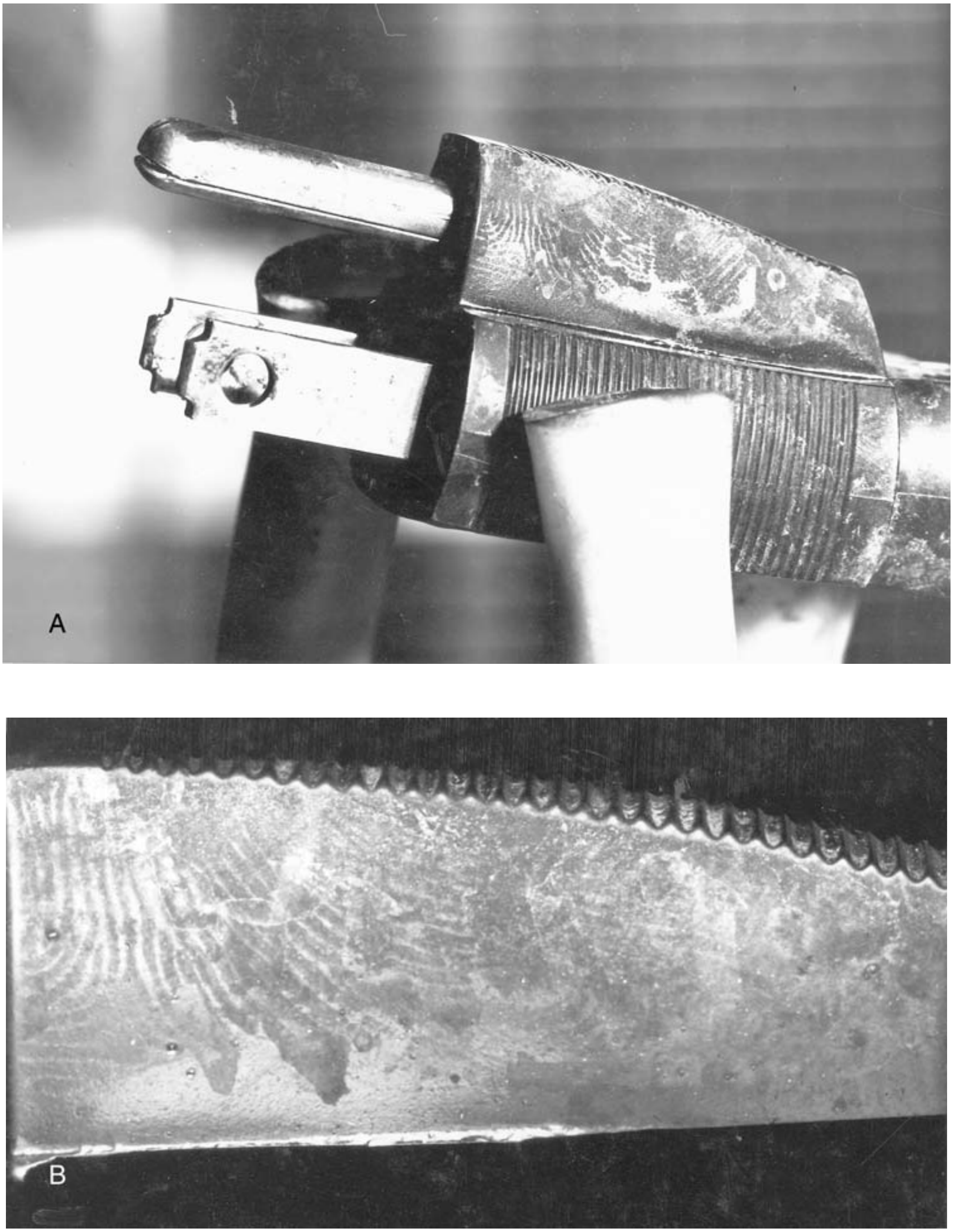

Figure 6.1 The suspect entered a convenience store in Kodiak, Alaska, where he robbed the clerk, hit her in the head with a gun, and forced her into a back room, where he tied her up with an electrical extension cord and attempted to rape her. The police developed a good suspect, but the clerk was unable to identify him. Inked finger and palm prints were submitted and identification was made from the latent prints developed on the plug (A and B) of the extension cord. *(Alaska Department of Public Safety, Scientific Crime Detection Laboratory, Latent Print Section.)*

worked with gloved hands, prints may have been left when a heavy piece of furniture was moved because the gloves may have slipped and a part of the wrist or palm left a print.

A flashlight is an excellent tool to search for prints. Fingerprints can frequently be seen by holding the flashlight at low angles so that the surface is observed under oblique lighting.

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Figure 6.2 (A color version of this figure follows page 256.) Using a personal workstation with a ductless fume hood is an effective means to reduce the amount of fingerprint powder in the workplace. *(Los Angeles County Sheriff's Department.)*

However, flashlights may not work on all surfaces. If prints are expected in a particular place and they are not discovered, the area must be examined by special methods described under the heading "Development of Latent Fingerprints."

During the search for prints, investigators should only wear gloves if blood is present. Investigators should become accustomed to working in a way in which they do not leave their own prints. If an officer should accidentally deposit fingerprints, this fact should be recorded so that he or she may later be eliminated from the relevant prints. All prints at the scene of a crime should be preserved, even if they are assumed to belong to the residents.

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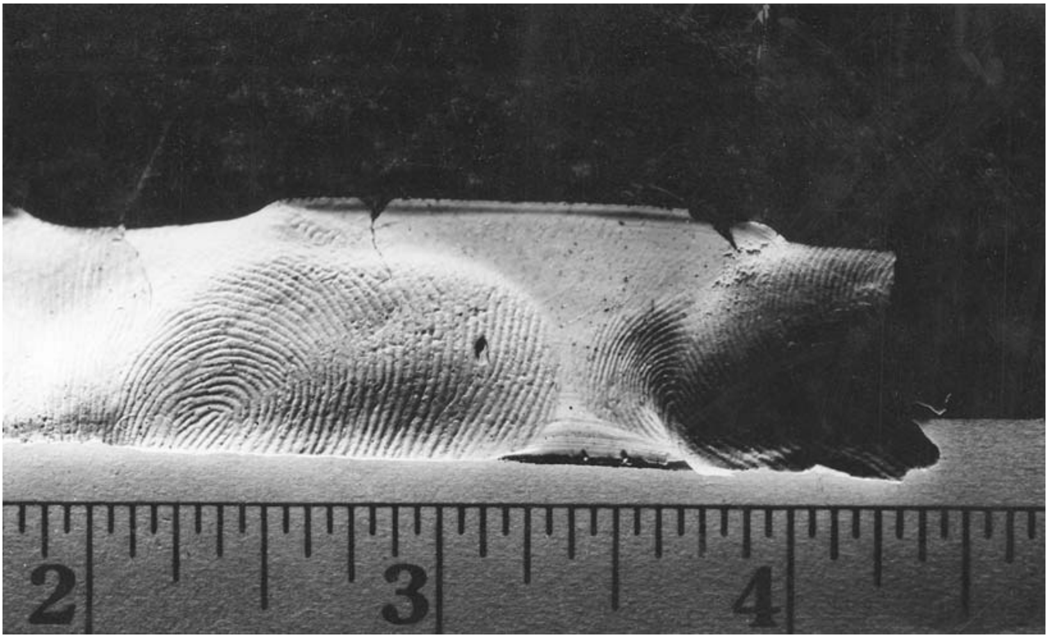

Figure 6.3 A plastic fingerprint in putty is sometimes found at burglary crime scenes. *(Los Angeles County Sheriff's Department.)*

Different Types of Fingerprints

Fingerprints can be divided into three main groups: (1) plastic fingerprints, (2) prints of fingers contaminated with some foreign matter or "visible prints," and (3) latent fingerprints.

- **Plastic fingerprints** occur when a finger touches or presses against plastic material and creates a negative impression of its friction ridge pattern. These prints are found on such materials as fresh paint, on substances that melt easily or soften when held in the hand (e.g., chocolate), on adhesive tape, in thick layers of dust, plastic explosives, putty that has not hardened, candle wax, sealing wax, fats, flour, soap, thick and sticky oily films, grease, pitch, tar, resin, and clay, to name a few (Figure 6.3).
- **Prints from fingers contaminated with foreign matter** are common. Dust prints occur when a finger is pressed in a thin layer of dust and some of the dust sticks on the friction ridges. When the finger is then placed on a clean surface, a fingerprint results. In some cases a dust print may be fully identifiable and may be clear enough to search in a single fingerprint file. Prints can be left when fingers are contaminated with other substances like pigments, ink, soot, flour, face powder, oils, safe insulation, or blood.
- **Latent fingerprints** result from small amounts of grease, sweat, and dirt deposited on a surface. Skin on the hands and soles of the feet has no oil glands. Grease found on fingers comes from other parts of the body that the hands touched. Secretion from friction skin contains 98.5 to 99.5% water; the balance is organic and inorganic components. If the hands are cold, practically no liquid is secreted; when they become warm, secretion returns to normal. Latent prints are most often found

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on objects with polished or smooth surfaces and on paper. However, under some conditions they may also be detected on rough surfaces, and even on smooth fabrics. "Latent prints" include those invisible to the unaided eye plus all others that are visible but only properly examined after development.

Fingerprint Developing Techniques

Many advances in fingerprint technology have occurred, such as techniques developed for visualizing prints. Most of these techniques involve chemical reagents that react with materials present in the components that make up the print or contaminants. Collaboration between forensic chemists and forensic identification specialists has made these techniques possible and continued effort is to be encouraged. Forensic chemists and criminalists should be assigned to identification units within laboratories to work with fingerprint and identification specialists to develop and use chemical-based fingerprint visualization techniques.

Many procedures are available to develop latent fingerprints.[2] Those listed in the next sections are some of the standard procedures in use; however, new ones are developed regularly. It is important to understand that practical experience with these procedures is needed to use them effectively. Certain of the methods work better than others do for different materials. The sequence of using these procedures is also important because it is possible to use multiple procedures, one following the other, to search for prints. Some procedures have an adverse effect on other types of evidence, e.g., certain solvents can cause inks to run on documents or render biological evidence unsuitable for typing. Latent fingerprint examiners are cautioned that they should understand these techniques before trying them on casework. Latent print examiners should work closely with forensic scientists to develop procedures for using chemical developing methods with safeguards to avoid destruction of other types of physical evidence. Latent print examiners should consider forming regional user groups to help keep up with rapidly changing technology. Such groups are made up of local practitioners who meet monthly and share technical experiences with other practitioners. These regional groups are especially helpful in small identification sections with only one or two examiners, who may be unable to attend technical conferences.

Development with Powders

Brushing fingerprint powder over a latent print makes the print visible. The substances that form the print show up and the print becomes fully visible. The choice of powder depends partly on the kind of surface on which the print is found and partly on how it is to be preserved. If the latent print is of high quality, the choice of material for development is not especially important. Several types of fingerprint powders are commercially available: black, white, colored, aluminum, copper, fluorescent, and magnetic. The type used is determined by the color of the background and the nature of the surface (for example, magnetic powder cannot be used on ferrous materials).

There is little safety information about fingerprint powder; however, common sense suggests that long-term exposure to fine particulate matter may cause respiratory problems

[2] The FBI has published an excellent reference work, Processing Guide of Developing Latent Prints, Revised 2000, available on its web page for download at: http://www.fbi.gov/hq/lab/fsc/backissu/jan2001/index.htm.

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over time. Persons who routinely use fingerprint powders can wear dust masks or specially designed fingerprint hoods to minimize the amount of powder breathed (Figure 6.2).

Fiberglass, animal hair, and synthetic or natural fiber brushes may be used to develop fingerprints. If the brush is damp or oily, it is useless. The brush is first lightly dipped in the powder and then tapped with the finger so that only a small amount of the powder is left on the brush. The object is then lightly brushed in curved strokes. Powder particles will adhere to all places where there is grease or dirt. If fingerprints are present on the object, they show up more or less clearly.

Powder should not be sprinkled over or tapped onto the object while brushing. Prints from sweaty or dirty fingers or produced by a firm grip may cause the friction ridges to spread out, filling up the spaces between the ridges. Too much powder can destroy these prints. If too much powder is used, it can be "washed" by pressing a fingerprint lifter against the print. The lifter will remove the excess and the spaces between the ridges may be nearly free of powder. If necessary, the latent print can be reprocessed to get usable results.

Some fingerprint examiners use black fingerprint powder as a universal developer on smooth nonporous surfaces. On dark surfaces, such as furniture and firearms, aluminum or copper powders give good results. These powders are useful if the print is to be photographed before being lifted. Remember: aluminum-powdered lifts appear reversed from prints developed with black powder.

Perspiration and grease from fingerprints absorb into porous surfaces such as paper and cardboard, and do not usually give results with powdering methods. On porous items, another method should be used, such as iodine, ninhydrin or silver nitrate treatment. Another

Figure 6.4 Magnetic fingerprint powders work well on some items. Only the rays of powder come in contact with the surface, as in this example on a plastic bag. *(Los Angeles County Sheriff's Department.)*

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aid to fingerprint development, the Magna-Brush®, utilizes magnetic powders and a magnetic applicator. Streamers of magnetized powder are brought in contact with the suspected surface. Powder adheres to the latent print, while the magnet removes the excess. This method has the advantage of not leaving excess powder on the object and the surrounding area. Because of the nature of the process, it can be used effectively only on nonmagnetic surfaces (Figure 6.4). Fluorescent powders are yet another type that may be used in some special cases. Available in powder and aerosol forms, these powders are used to dust paper currency and documents and sprayed in areas where recurring thefts take place. They are technically not fingerprint powders because they are used prior to the prints being deposited.

After the suspect has handled the money or touched the dusted area, the area is examined with ultraviolet light. The latent fingerprint is easily visualized by UV light and may be photographed using proper photographic techniques.

Amido Black. This stain turns proteins present in blood blue-black. It does not react with any of the normal components of fingerprints and should be used in conjunction with other developing techniques. Other more sensitive stains such as Coomassie blue, a general protein stain used in forensic biology, may be considered. Fingerprint specialists should always consult forensic biologists before using any protein stains on bloody fingerprints because some stains may cause difficulties in blood testing.

DFO (1,8-diazafluoren-9-one). DFO is a ninhydrin-like analogue. It reacts with proteins to give a highly fluorescent, red-colored product that is more sensitive than ninhydrin. Although some prints developed using DFO will be visible to the naked eye, illumination with high-intensity light improves the sensitivity; however, interference may become a problem from certain colored inks and papers that fluoresce. Longer wavelength light sources, such as mercury vapor lamps at 546 nm lessen the interference. Ninhydrin may be used in conjunction with DFO; however, DFO must be used first.

Fluorescence examination. Using lasers, alternative light sources or ultraviolet lamps on untreated surfaces may yield prints. Various naturally occurring chemicals and contaminants present in latent prints fluoresce without treatment with laser-sensitive dyes. Although the chance of finding autofluorescent latent prints is limited, the ease of the procedure suggests its use.

Gentian violet or crystal violet. These dyes, which produce a purple color, stain fatty components of latent prints and are especially effective when used on the sticky side of adhesive tape. The material is toxic and appropriate laboratory precautions must be taken. Using a laser increases the sensitivity of the procedure. A yellow-orange light source yields the best results, e.g., a copper vapor laser at the 578-nm line. An alternative dye, Basic Fuchsin, yields good results with green excitation and has an absorption maximum at about 500 nm (Figure 6.7).

Iodine. Iodine is one of the oldest methods of visualizing latent prints on porous and nonporous substrates. The technique is simple to use; however, iodine vapors are toxic and corrosive and the reaction is not permanent. Methods have been introduced for fixing prints developed by iodine fuming, e.g., 7,8-benzoflavone, which also increases sensitivity.

Ninhydrin solution. Ninhydrin is another technique for use with porous surfaces, e.g., paper, cardboard, wallboard, and raw wood. Ninhydrin reacts with amino acids to form a purple-colored compound called "Ruhemann's Purple." The reaction is speeded up by means of humidity and elevated temperatures. Treating with zinc chloride solution and viewing with a laser improve sensitivity of the techniques. Background fluorescence may be overcome by using cadmium nitrate solution cooled to liquid nitrogen temperatures and viewed with a laser. Modifications to the chemical structure of ninhydrin have been

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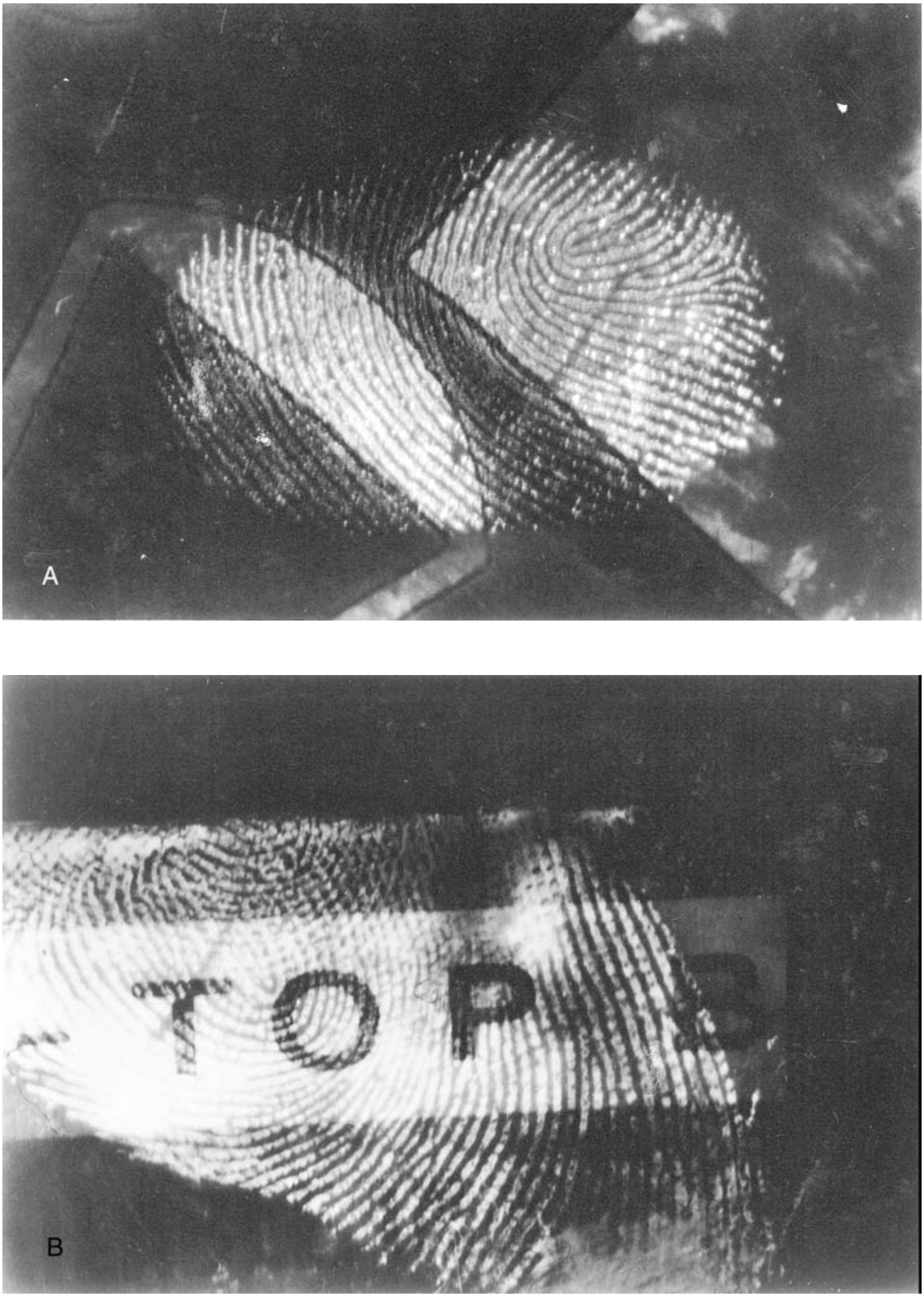

Figure 6.5 Latent prints can be developed using a combination of cyanoacrylate, or superglue, and fluorescent powders or dyes that can be visualized under ultraviolet light, laser, or alternative light sources. (A) and (B) are latent prints developed on multicolored, glossy-coated papers. *(Zurich Cantonal Police, Forensic Science Department.)*

synthesized and show usefulness under certain conditions. The importance of these analogues is that they fluoresce at different wavelengths and provide a way to overcome background interference from certain substrates.

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Figure 6.6 (A color version of this figure follows page 256.) Using a humidity cabinet speeds up the ninhydrin reaction to proteins found in fingerprints. *(Los Angeles County Sheriff's Department.)*

Physical developer (PD; also called stabilized physical developer, or SPD). PD is a silver-based solution used as a substitute for the conventional latent print silver nitrate procedure. PD is useful in detecting latent prints on porous surfaces that are wet or have been wet, e.g., paper, cardboard, and raw wood. The technique may be used following ninhydrin. PD reacts with components of sweat and appears in shades from gray to almost black. PD-developed prints are preserved by photography.

Silver nitrate. Silver nitrate solution reacts with chlorides in prints, but with the advent of PD it is not in widespread use. It may have some application on raw wood; however, the background staining of the substrate may cause problems in photography.

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Figure 6.7 (A) Adhesive-backed tapes are an excellent substrate on which to locate fingerprints. The difficulty is removing the sticky tape from surfaces. Denis E. Kebabjian, a forensic scientist with the New York State Police laboratories, developed a simple technique for removal by using liquid nitrogen *(New York State Police, Albany, New York)*. (B) Gentian violet is a technique sometimes used to visualize latent prints on the sticky side of adhesive tapes. *(Zurich Cantonal Police, Forensic Science Department.)*

Small particle reagent (SPR). This is a wet process for developing latent prints on wet surfaces. The reagent is a suspension of molybdenum disulfide particles prepared in a detergent solution. Molybdenum adheres to lipids found in prints as a gray deposit. The process works well on nonporous surfaces, e.g., plastic bags, wax paper, glass, and painted surfaces, and may be used effectively on water-soaked firearms. Visible prints may be lifted and/or photographed.

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Sudan black. This process is used on nonporous articles, e.g., glass, plastics, and metal. Usually less sensitive than SPR, it may be the method of choice if the substrate is oily or greasy. Sudan black reacts with the lipid components of prints and stains them blue-black. It is messy to use and not effective on dark-colored objects.

Superglue or cyanoacrylate fuming. Superglue is used on nonporous surfaces to produce visible prints that are white. The visible prints may be dusted with powder, photographed and lifted, or washed with laser-sensitive dyes such as Rhodamine 6G and others, and viewed with lasers or alternative light sources. Superglue is one of the easier procedures to use; however, in some instances, other latent print visualization techniques may yield superior results (Figure 6.9).

Vacuum metal deposition (VMD). VMD is an effective technique for most smooth, nonporous surfaces, e.g., plastic bags, plastic packaging material, and other smooth surfaces. The major drawback to vacuum metal deposition is that the equipment is expensive and the sample chamber of the vacuum coater is not very large. The procedure evaporates gold or zinc in a vacuum chamber and a very thin film of the metal is deposited onto the latent print, making it visible.

Lasers and Alternative Light Sources

The word laser is an acronym for light amplification by stimulated emission of radiation. The use of lasers and other alternative light sources has become a very important adjunct to locating and visualizing latent fingerprints as well as other types of physical evidence such as trace evidence and certain types of biological evidence.

Several types of lasers and so-called "alternative light sources" (high-intensity arc lamps) are in current use. No light source is best in all forensic applications. Several factors need to be considered in choosing the type of high-intensity light most suitable for use in a forensic laboratory or for field applications. Some of the factors that must be considered are: cost, color of light or wavelengths available, light intensity or power output, portability, voltage requirements, safety, available service on an emergency basis, and the ability to use the unit in other forensic applications.

Cost is a factor to consider because none of these devices is inexpensive. Some require special setups and workspace remodeling, e.g., darkened work areas to take photographs, laboratory sinks and fume hoods to handle light-sensitive dyes, power requirements, plumbed in water to cool the unit or additional units to recirculate coolant to the laser, liquid nitrogen for use in certain laser procedures — the list can be formidable and must be considered when budgeting for a unit. Other costs include maintenance and purchase of component parts that must be replaced from time to time.

Not all devices are suitable for forensic latent print work. The wavelengths of the output,[3] as well as the light intensity or power output, is important. Initial studies using lasers for latent fingerprint detection used an argon ion laser and, later, copper vapor and portable neodynium:yttrium aluminum garnet (Nd:YAG) lasers. The working frequency of these lasers determined the laser dyes and visualization techniques that were first developed. Alternative light sources such as xenon arc lamps seem to produce comparable results and have become more available. Some lamps have broad light frequencies (250 to 1100 nm), although their light intensities are not as great as some lasers. Alternative light

[3] Some lasers and alternate light sources can be varied to produce different wavelengths of light.

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Figure 6.8 (A color version of this figure follows page 256.) The vacuum metal deposition places a thin film of gold followed by a film of zinc on latent prints left on smooth surfaces such as plastic bags. VMD is a very sensitive technique for fingerprint development on non-porous and semiporous surfaces. *(Los Angeles County Sheriff's Department.)*

sources have the additional benefits of being less costly and more compact (thus, more portable) than some lasers.

Safety is a concern with lasers and alternative light sources. The high intensity of the light can cause eye fatigue and eye damage. Persons working with these tools should be required to wear appropriate eye protection to minimize any damage.

Image Processing

New technology is being used to enhance latent prints that heretofore were of insufficient

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Figure 6.9 Latent prints developed using cyanoacrylate or superglue on a pistol. *(Los Angeles County Sheriff's Department.)*

computers precluded the use of such technology in most crime laboratories. Major advances in the computer industry and the resulting proliferation of relatively inexpensive Pentium class computers have placed image processing technology within the budgets of most laboratories.

Latent prints are examined by means of a high-resolution video camera whose output signal is fed into a computer. Unlike the human eye, the computer is capable of distinguishing among the hundreds of shades of gray that show up as varying degrees of density captured in the image. The computer in turn can process the digital image in several ways. The image can be shown in reverse video (equivalent to a photographic reversal or negative) or in color. This is particularly advantageous if the print is on a textured surface that makes it difficult to examine because of the background pattern interfering with the ridge detail of the print.

Various light sources — visible, infrared, ultraviolet, high intensity, laser, filtered, and unfiltered — give considerable range to latent print identification. Digitizing images along with readily available computer software gives excellent results.

Automated Fingerprint Identification Systems

Automated fingerprint identification systems (AFIS) represent the single biggest advance in fingerprint identification technology. Heretofore, the ability to compare a latent fingerprint discovered at the crime scene with a criminal fingerprint database was, for all intents and purposes, impossible. The amount of human effort to conduct a manual search for a latent print against several million inked prints is astronomical and prior to AFIS was simply out of the question.

Cold searches or searching a database of several million prints for a single latent found at a crime scene is a daily occurrence. Even more staggering, the search of prints on file in an AFIS database only takes about 10 minutes.

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Figure 6.10 The polylight is one of several alternate light sources in use today in modern law enforcement agencies.

AFIS has revolutionized the way police departments search latent prints for matches. At one time, it was not uncommon for some crime scene investigators to dust low property value crime scenes to placate crime victims who wanted the police to do something. The effort put into dusting a scene seemed to give victims a feeling that the police were doing something. In only a small percentage of cases would latent prints be matched to those of a criminal. Some police administrators even questioned the value of going through the effort of trying to locate fingerprints in low property-value, residential burglaries and automobile burglaries.

AFIS has completely changed that way of thinking. Simply stated, the more AFIS quality latent prints collected at crime scenes, the greater is the chance of identifying criminals by automated fingerprint identification systems.

Several AFIS technologies are in use today. The main drawback at present is that they are not compatible to one another. Prints stored electronically in one state's AFIS database cannot be searched by a system sold by another vendor. The only way around this shortcoming is to input the latent, or a copy of the latent, into the other AFIS system. Computer software and hardware to bridge that gap will improve the usefulness of AFIS technology.

The quality of the inked fingerprint cards used to create the AFIS database is critical. Poorly taken criminal-fingerprint cards input into the AFIS database eliminate the

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possibility of making a correct identification when conducting a latent print search. Because a surprisingly high number of crimes may be associated to one perpetrator, the quality of the inked fingerprints and the AFIS data entry process become very important.

A new alternative to taking inked prints is an electronic technique whose generic name is Livescan. Livescan technology produces high-quality print cards without the need to take inked prints. Each finger is inserted into a reader and its fingerprint is captured. At the end of the process, a standard print card is produced. The next step of the process is to input the print card into the AFIS database. A shortcoming of the system is that AFIS systems are proprietary and Livescan systems cannot transfer electronic data directly into AFIS.

Preservation of Fingerprints

Preservation by Photography

Fingerprints found at the scene of a crime should be preserved by photography when possible. This procedure has many advantages. Photography leaves the objects intact so that further photos can be taken if the first are unusable. It also makes it easier to show the evidence in court because the object on which the latents were discovered can be seen in the picture. The photography of fingerprints and other evidence differs from ordinary picture taking. The photographer must be skilled in photographic techniques and understand how to obtain a reproduction of a fingerprint as accurate and true to the original as possible. Additionally, knowledge of the principles of fingerprint comparison is helpful to appreciate what the person making the print identification requires. The finished photograph should be white on a black background or black on a white background. It should be 1:1, the actual size, and a ruler should be included in the photograph to allow for the printing to be 1:1. The person taking the photograph should advise the person making the fingerprint comparison whether the print is a direct or mirror image or a positive or negative image.

If the print is visible without development, it should be photographed as found, in view of the possibility that any measures taken for development might destroy it. This can generally be done by a suitable arrangement of lighting. An attempt can then be made to make the print clearer, for example, by treatment with powders, after which more photographs are taken. A number of police equipment supply companies sell "fingerprint cameras" or close-up cameras with built-in light sources that work well. Polaroid has a fixed-focus close-up camera with ring light attachment that gives excellent results, as does the Kodak Ektagraphic® EF Visualmaker unit. The latter has built-in batteries, while the former comes with a portable battery pack. These cameras are intended for close-up photography only and cannot be used for routine crime scene work.

An alternative to the fixed-focus camera is the 35-mm camera with close-up lens, extension tubes, or a bellows attachment. The 35-mm camera provides the added benefit of focusing on a ground glass screen rather than through a viewfinder. The camera can be placed on a tripod or hand held, depending on the lighting conditions. Fingerprints should be photographed with a scale in the picture if 1:1 enlargements are desired.

Preservation of Plastic Fingerprints

When a fingerprint has been left in material that has hardened or is able to withstand transport and when it is on a small, easily transportable object, it may be sent directly to the crime laboratory. If removing the plastic print poses some special problem, it should

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be photographed using oblique light to bring out as much detail as possible. An appropriate casting material may then preserve the fingerprint impression.

Frequently, curved surfaces with latent fingerprints present, such as doorknobs, are difficult to photograph or do not lend themselves to the use of cellophane lifting tape. For such surfaces, elastic or rubber material works well. Rubber lifters are commercially available items made of a thin, rubbery material coated with an adhesive. A transparent celluloid material removed prior to use and replaced after use protects the adhesive. The color of the lifter is either black or white for use with different fingerprint powders.

To use this technique, the latent fingerprint is first dusted with an appropriately colored fingerprint powder. The protective covering of the lifter is pulled away and the sticky surface is pressed against the print and then pulled away. Part of the powder sticks to the lifter and gives the mirror image of the print. After the print is collected, the protective covering is carefully replaced on the lifter.

The lifter comes in different sizes and can be cut for a specific use. It is useful for picking up footprints in the dust as well as fingerprints. The lifting method is simple and easy to master. It requires no knowledge of photography and no photographic equipment. Its use, however, requires greater accuracy in specifying the position of the print. Carelessness in this respect can have disastrous results.

Preservation with Fingerprint-Lifting Tape

The most common method of collecting latent fingerprint evidence today is by special transparent cellophane tape. The material is supplied in rolls and is usually 1 or 2 inches wide. After the surface is dusted with fingerprint powder, the tape is placed over the print. Care must be taken to prevent any air pockets. The tape is smoothed down over the print with the aid of a finger and then drawn off. Particles of fingerprint powder adhere to the sticky surface of the tape and thereby transfer the fingerprint pattern. The tape is finally placed on a card whose color contrasts with the color of the powder used.

How Long Does a Fingerprint Remain on an Object?

Plastic prints remain for any length of time provided that the object on which they are left or the substance in which they are formed is stable. In investigations, it sometimes happens that police officers find fingerprints that give the impression of having been made in dust, but on closer examination are found to be dust-filled plastic prints in oil paint made years earlier.

Prints that have resulted from contamination of the fingers with soot, flour, face powder, or safe filling are soon destroyed. Prints of fingers contaminated with blood, pigments, ink, and oil are more resistant and can be kept for a long time under favorable conditions.

Latent prints on glass, china, and other smooth objects can remain for years if they are in a well-protected location. On objects in the open air, a print can be developed several months after it is made. Fingerprints on paper are very stable and will last for years, provided the paper does not become wet and deteriorate.

The Effect of Temperature Conditions on the Possibility of Developing Fingerprints

When objects that may contain fingerprints are found outdoors in ice or snow, they must be thawed slowly and placed so that the thawed water does not run over and destroy the

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prints. A suitable method of treatment is to scrape away as much snow and ice as possible, with the greatest care, before the object is brought to a warm place. Only when the object is dry should the print be developed.

When plastic fingerprints are present in oil or grease, the thawing must be allowed to proceed slowly and under close scrutiny because the print may easily be destroyed by heat. Such prints should be photographed when they appear.

Damp objects should be dried indoors at ordinary room temperature. As a general rule, never examine cold objects, especially metal, until they have been kept for at least some hours at room temperature. In indoor investigations in a cold house, the rooms should first be heated. The heating should be done slowly so that water from thawing does not run off frosted objects or places.

Examination of Developed Fingerprints

The officer who investigates the crime scene should only search for, develop, and preserve the fingerprints. Unless specially qualified by training and experience in the identification of fingerprints, the officer cannot be expected to carry out the continued examination of the developed prints.

A detailed account of fingerprint identification is not included here, partly because it lies outside the scope of crime scene investigation, and partly because it is a vast and specialized subject. Several comprehensive works on this subject are available.

The officer examining the scene should preserve all developed fingerprints. Even small, fragmentary prints that might seem insignificant to a nonspecialist may turn out to be very valuable when examined by an expert. Large fingerprints are not necessarily more valuable than small ones. It happens frequently that the larger print is usable only for comparison with a suspect's fingerprints; it is useless for searching in a single fingerprint file. The smaller print, however, may be usable for both purposes.

Palm Prints

Patterns of friction skin are on the inside of the hand just as they are on the fingers and they are of equal value as evidence. When part of a palm print is found, the area involved can often be deduced from the position of the print, or from other parts of the hand and possibly fingers having left marks in the form of smears or portions of print. If the position of the hand represented by the fragment can be estimated, a simple sketch of the inside of a hand greatly facilitates the expert's work.

Prints from the Sole of the Foot

Friction ridges on the soles of the feet have the same evidentiary value as fingerprints and are developed and preserved in the same way as other prints. Cases sometimes occur in which burglars lacking gloves for their hands have taken off their socks and put them on their hands to avoid leaving fingerprints. The thought of leaving footprints never entered their minds!

Packing Objects on Which Prints Are Found

The crime scene investigator must decide the best way to transport objects that are to be examined for fingerprints. Wrapping such items directly in paper, cloth, or plastic bags

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should be avoided because prints may be destroyed. If possible, the object should be wedged firmly in a strong box so that the packing does not touch the surface. Because a rigid suspension can cause breakage or other damage to an object in transit, the box must be wrapped in a sufficient quantity of soft material such as cotton, corrugated paper, crumpled newspaper, etc. If nails are used to fix the object in the box or for the lid, they should not be hammered completely in; the heads should be left free so that they can be pulled out without using much force.

Taking Fingerprints for Elimination

As a rule, persons who have legitimate access to the premises leave the majority of fingerprints found and developed at the crime scene; thus, it is important to eliminate these fingerprints so that the continuing examination may concentrate upon the remaining prints — presumably those of the perpetrator. The investigating officer should, therefore, always take elimination prints of all persons on the premises. These should be submitted to the fingerprint examiner together with the crime scene prints. Because the identification of legitimate fingerprints is as critical as the identification of the criminal's prints, the elimination prints should be as clear as a criminal's prints recorded for filing purposes. Elimination prints should therefore be taken by printer's ink or by specially prepared inkpads. It is not required, however, that they be recorded on standard fingerprint forms as long as they are clearly marked as being for elimination purposes.

A large proportion of latent prints developed at a crime scene are palm prints; therefore, elimination palm prints should also be taken. Inked palm prints require special care in order to be useful for comparison purposes. The palm should be inked with a roller to ensure that all parts of the palm are inked. The prints should be made on a sheet of white paper. Place the inked palm flat on the paper and press on the center of the top of the hand.

Prints of Gloves

The general knowledge of the value of fingerprint evidence has resulted in criminals using gloves as the most usual protective measure. In many cases, when an investigator is looking for fingerprints, glove smears are found and, all too often, little attention is paid to them. The search is concentrated at places where it may be expected that the individual would have preferred to work with bare hands and used a good deal of force so that his gloves would slip and the wrist, or a part of the palm near the wrist, would be exposed, leaving an imprint.

Prints of gloves, however, may be just as valuable as fingerprints so it is advisable always to examine and preserve them for closer investigation as long as they are not typical smears formed by the glove-covered hand slipping against a surface. The leather of a glove shows a surface pattern that is often of a very characteristic appearance. It may show furrows in a more or less definite pattern or be perforated in a fairly regular manner. It is much the same with fabric gloves. The surface pattern varies according to the method of manufacture and the yarn or material used. It is the wrinkled or textured surface pattern of leather gloves that can make identification possible (Figure 6.11).

In contrast, the surface pattern of fabric gloves is regular for each type so, in general, identification cannot be based merely on this. Characteristic and, from the point of view of identification, very valuable formations in the seams may be present, especially at the tips of the fingers. After they have been worn for some time, leather or fabric gloves become

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Figure 6.11 (A color version of this figure follows page 256.) Animal hide is friction ridged and smooth like human skin. It is individual in its minute characteristics and can be conclusively identified. The latent glove print (A) was compared with the test print (B) on the basis of the size, shape, orientation, and interrelationship of "plateau" areas delineated by tension lines in the leather. Three areas have been darkened to serve as a starting point in the comparison. *(Contra Costa County Sheriff's Department, Criminalistics Laboratory, Martinez, California.)*

shaped to the hands, and typical wrinkle formations often are produced in the leather of the fingers, at the seams, or at places where the gloves do not fit the fingers properly. These wrinkle formations and injuries in the form of tears or holes or, in the case of leather gloves, cracks in the surface of the skin generally show in the print and are most valuable. In rare cases, it is even possible to find fragments of a fingerprint within a glove print. This can occur when the gloves have such large holes that some part of a finger is exposed and leaves a print at the same time as that of the glove.

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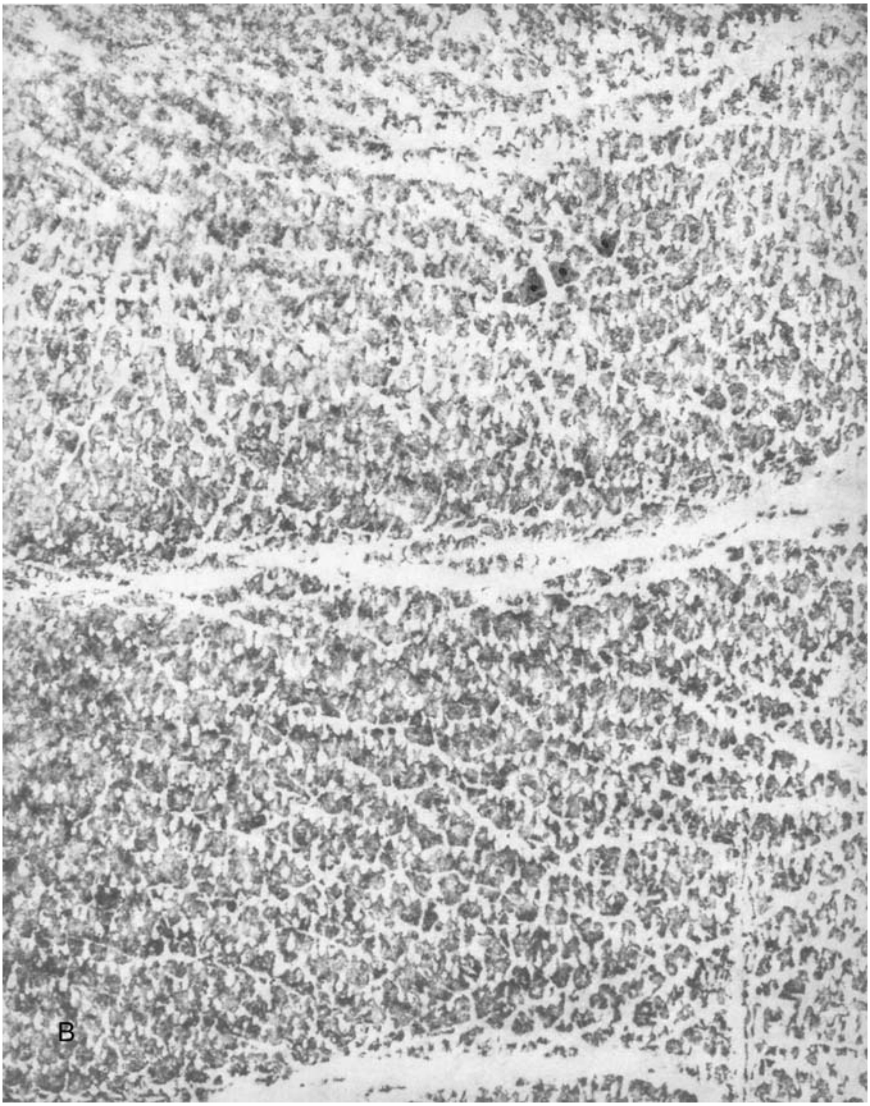

Figure 6.11 (continued)

If prints of gloves and friction ridges appear together, it may be difficult to distinguish the difference without closer examination. At first glance, the print gives the impression of being blurred or composed of two glove prints within each other. On closer examination, however, its regular lines, which lack the detailed pattern of the friction ridges, distinguish the glove print. Glove prints are always formed best on smooth surfaces. Their development requires great care because the prints are not as strong as fingerprints and therefore are easily destroyed if too much powder is used. To ensure not destroying any such prints that may be present at the scene of the crime, the area should not be painted vaguely. A systematic search may be made with the aid of a lamp and then cautious brushing. On the other hand, there is the prospect of finding glove prints at conspicuous and easily accessible places because, in most cases, the criminals abandon all caution and believe that they are fully protected by their gloves and so use their hands freely.

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In developing prints, white or black powder may be used. A fingerprint lifter can lift the developed print, but it is better to take possession of the object on which the print is found so that it can be compared directly with prints from the gloves of a suspect. Leather or fabric gloves can produce a print. With the former, the leather contains some fat, while both leather and fabric gloves become contaminated with dirt, skin grease, and the like after being in use for some time. In addition, the warm and moist secretion from the skin of the hands plays an important part, at least with fabric gloves.

Comparison prints from the gloves of a suspect are best made on glass, which is generally most convenient even when the original prints are on furniture. In certain cases, however, it may be necessary to form a print on the same kind of material as that at the scene of the crime. Where possible, such material should be packaged separately when a print and gloves from a suspect are sent for examination. Comparison prints should be made in a manner similar to that used for the original ones. For example, if it is possible to decide how the hand of the suspect gripped the object, this information should be communicated to the expert so that the same grip can be applied for the comparison print. Consideration must also be given to the degree of pressure that may have been used in forming the original print and this should be noted. It is important that neither too much nor too little pressure be used in making the comparison prints because the appearance is greatly affected by pressure.

It is often difficult to make clear prints with a glove, but breathing slightly on the finger of the glove may assist the operation. In certain instances, it may be treated with powder, fat, or the like; however, this technique risks destroying any characteristic details.

Prints of Other Coverings

Instead of gloves, other items such as socks, towels, and handkerchiefs are sometimes used as protection for the hands. It has also happened that individuals have protected the insides of their hands with adhesive tape to prevent the formation of fingerprints. In most cases, when using the first-mentioned objects, prints are left only if the material is thin, dirty, or somewhat damp. If, however, it is thick, dry, or relatively clean, it leaves no prints. Prints of such hand coverings rarely have any value from the point of view of identification. Identification is possible only in cases in which the material used has a characteristic surface pattern and shows typical injuries, unusual seams, or characteristic crease formations that are reproduced in the print. In such a case, the investigation is tedious because the extent of the edges of the protective medium is not definitely fixed as it would be in the case of a glove; therefore, it must be searched for before a direct comparison can be undertaken.

Although the possibility of identification of hand coverings in such cases is not great, the print should still be given some attention because the method of operation may be typical for a particular individual or gang who have perhaps carried out other crimes in the same or another area.

Latent Fingerprints on Human Skin

Techniques devised for developing latent fingerprints on human skin have been successful only in rare instances; however, they may be attempted in certain cases. The procedures are simple to use, inexpensive, and can be accomplished by evidence technicians. The procedures work on living and deceased subjects (Figure 6.12).

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Figure 6.12 Prints developed from a body by dusting the surface using the Magna Brush and photography. *(Metropolitan Dade County, Office of Medical Examiner, Miami, Florida.)*

The first technique is the Kromekote® Lift Technique. The equipment needed includes a fiberglass filament brush, fingerprint powder, and Kromekote cards. Kromekote cards are approximately 5- × 7-inch, high-gloss, 80-lb paper similar in appearance to photographic paper. Kromekote is generally available from local paper suppliers. The Kromekote card is used to lift the print from the skin surface by placing the card over the skin in the suspected area and applying pressure for about 3 seconds. The card is carefully removed and then dusted with black fingerprint powder to develop the print transferred onto the card. The fingerprint obtained is the mirror image of a normal print and can be reversed through photography.

After the Kromekote technique is used, fingerprint powder can be applied directly to the skin to develop prints. The literature reports that the Magna-Brush gives results superior to a fiberglass filament brush. If a print is developed by this method, it must be photographed and then may be lifted using cellophane lifting tape. Fingerprints on skin surfaces appear to last about 1.5 hours on living victims. Deceased victims should be examined for latent prints on the skin as soon as possible. The technique is still somewhat experimental, but the method's simplicity and ease of use will result in greater use on the part of experienced investigators.

Obtaining latent prints from skin is still in an experimental stage and with continued research may one day prove to be routine procedure.

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Handwriting Examination

Handwriting is another means of establishing identity. Like fingerprints, it offers the investigator the ability to establish the identity of an individual conclusively. Handwriting characteristics are of two types: style characteristics and personal characteristics.

Style characteristics are the general type to which cursive writing belongs. This general type is learned in school and used by almost everyone. Personal characteristics are changes made in the general style characteristics both intentionally and unconsciously by the writer. Personal characteristics are the ones used to establish the identity of the writer. Handwriting examination can be used to answer two questions: (1) was a signature or document a forgery and (2) were two writings made by the same person? To answer these questions, the document examiner makes a careful examination of the questioned writing and known exemplar writings. Factors such as the relative size of letters, their slope and spacing, the way in which they are formed, and other personal characteristics are used to make a determination.

Written documents occur in every facet of today's society. Daily business transactions include the use of checks, credit card receipts, money orders, purchase receipts, and so forth. Writings may occur on paper as letters and notes, but also may be present on desks, tabletops, walls, floors, doors, and even on dead bodies. Wherever they occur, they should not be overlooked. Once a document is discovered, it must be properly handled and preserved. Failure to do so may result in its inadmissibility as evidence.

Excessive handling may damage the document and smudge or obscure important writing characteristics, which may preclude any possibility of identification and eliminate latent fingerprints. The document should be preserved in the same condition in which it is found. Generally, this is best accomplished by placing it into a clear plastic envelope or sheet protector that keeps the document clean, preserves fingerprints, and prevents damage or destruction of minute identifying details. If the document is wet or soaked with blood, it should first be allowed to air-dry at room temperature and be placed in a cardboard box for delivery to the laboratory. Documents should be handled with forceps so as not to leave prints that may confuse subsequent tests for fingerprints.

Documents should not be altered in any way and should not be folded or creased. If the document is damaged or torn, no attempt should be made to repair it. The investigator should not write on the document to identify it. Documents should not be stapled together or to reports. If the document is stapled, the staple should be removed slowly and carefully so as not to tear the paper. A staple remover should not be used. Do not use a paper punch on a document. Documents should not be left under paper on which the investigator may be writing because indentations may damage the identifying characteristics on the questioned writing. The side of a lead pencil should not be rubbed across the document in order to observe indented writing. Stickers or gummed labels should not be affixed to the document.

The suspect should never handle the document during the course of the investigation. If chemical processing to develop fingerprints on documents is used, the document should first be photographed with a document scale present. After the chemical processing is completed, the paper should not come into contact with other papers because the stain can transfer. Paper should not be handled because additional fingerprints and smudges can easily be deposited onto it. Chemically processed documents should be kept in clear plastic envelopes or sheet protectors.

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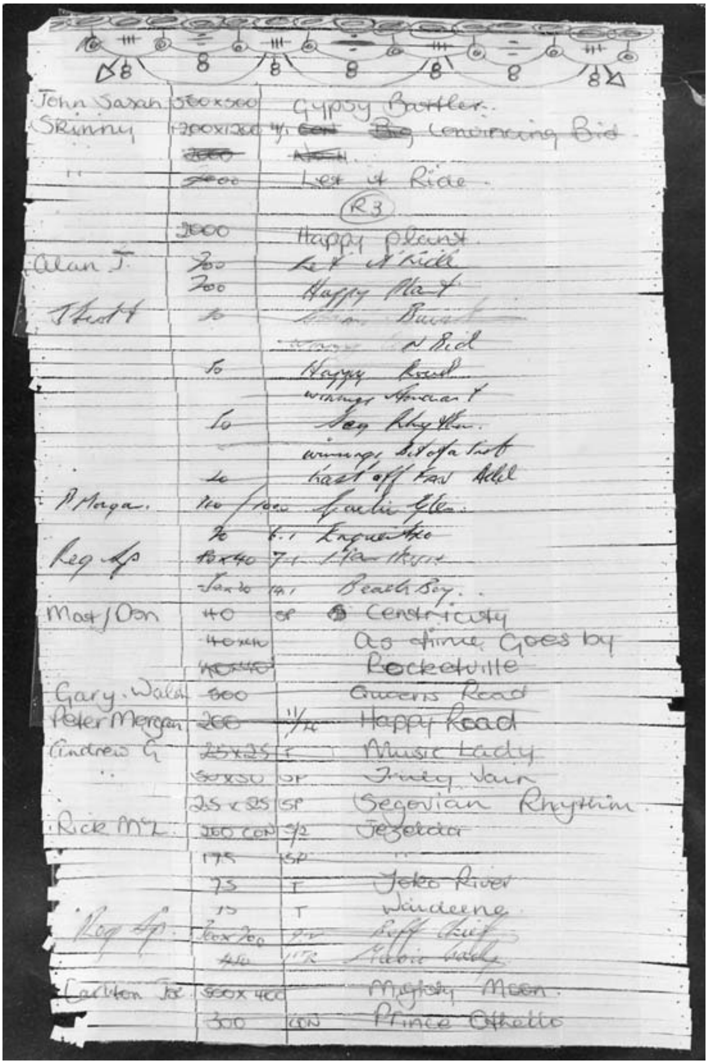

Figure 6.13 Reconstructing shredded documents in a bookmaking investigation is very time consuming, but it is an integral part of the prosecution's evidence. *(State Forensic Science Laboratory, Melbourne, Australia.)*

Documents damaged by fire could contain information valuable to the investigation. Arson has long been used in insurance fraud or to conceal another crime. If possible, burned documents should be left in their container and handled as gently as possible. (Refer to Chapter 7 for a more detailed discussion of preserving burned documents.)

If questioned writings are found on a wall or body in a homicide case, it is advisable to contact a document examiner for possible assistance at the crime scene. If this is not possible, photographs should be taken of the area. Writings on walls, desktops, mirrors, and other surfaces should be photographed with a scale present. If possible, the item containing the writing should be removed and submitted to the laboratory. If the writing is confined to a relatively small area, such as a wall, and circumstances justify it, the section should be cut out and taken to the laboratory.

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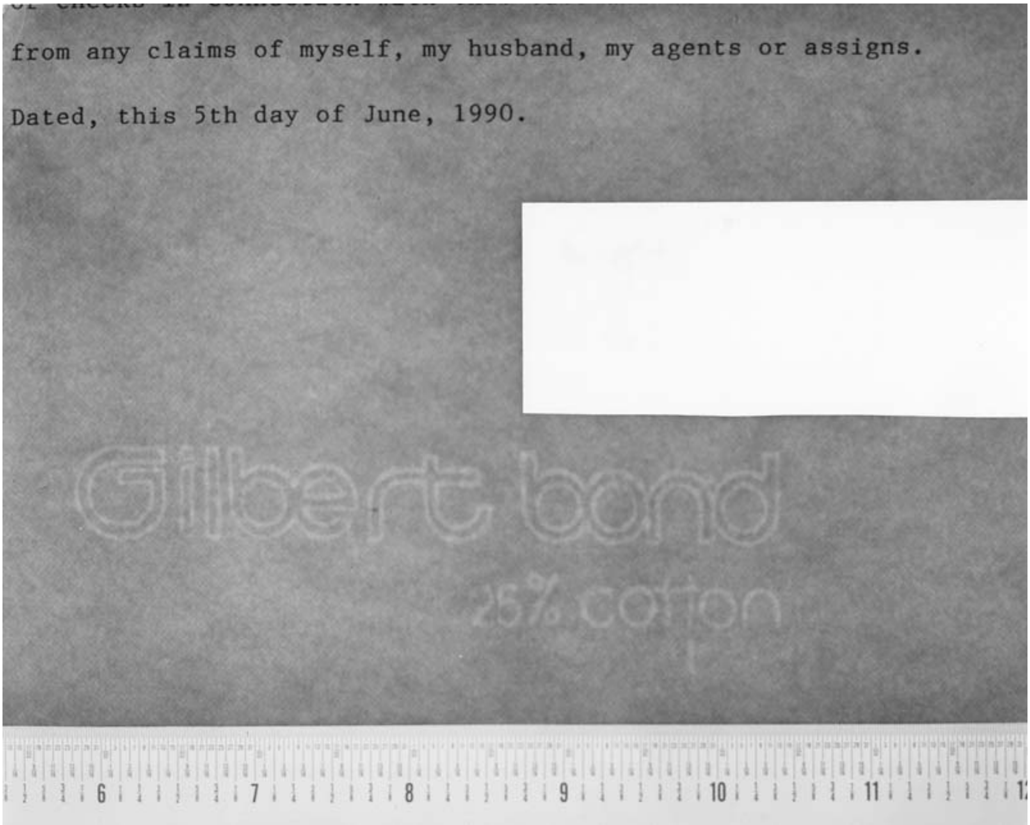

Figure 6.14 Watermarks on paper may sometimes be used to date a document. In this case, a watermark on a document along with the code provided by the manufacturer was used to show that a document was dated prior to the date shown by the watermark. *(Indiana State Police Crime Laboratory.)*

It is necessary to mark documents that later may be entered into evidence during presentation of the court case. The best place to mark a document is usually on the back. This should be done inconspicuously with initials and date and as far away from other writings as possible. In the event this is not possible, the best solution is to use a pen with a different color ink so that the marking cannot be confused with the questioned writing. Red ink should be avoided because it does not survive well when ninhydrin is used to develop latent fingerprints. Extraneous markings and writings should never be placed on the document. If additional information beyond the investigator's initials and the date is necessary, it should be recorded in the officer's notes. It is generally necessary to store documents for varying lengths of time, sometimes several years, pending final disposition of the case. The documents can be stored in protective plastic envelopes or sheet protectors and filed in folders or envelopes large enough to keep them flat. In this way, they will remain in good condition for long periods of time. Photographs can be kept in flat folders or envelopes. Documents processed for fingerprints with ninhydrin or other chemicals must be enclosed in clear plastic envelopes or sheet protectors. Documents should be stored in an area with a relatively cool, dry temperature and away from excessive heat or direct sunlight.

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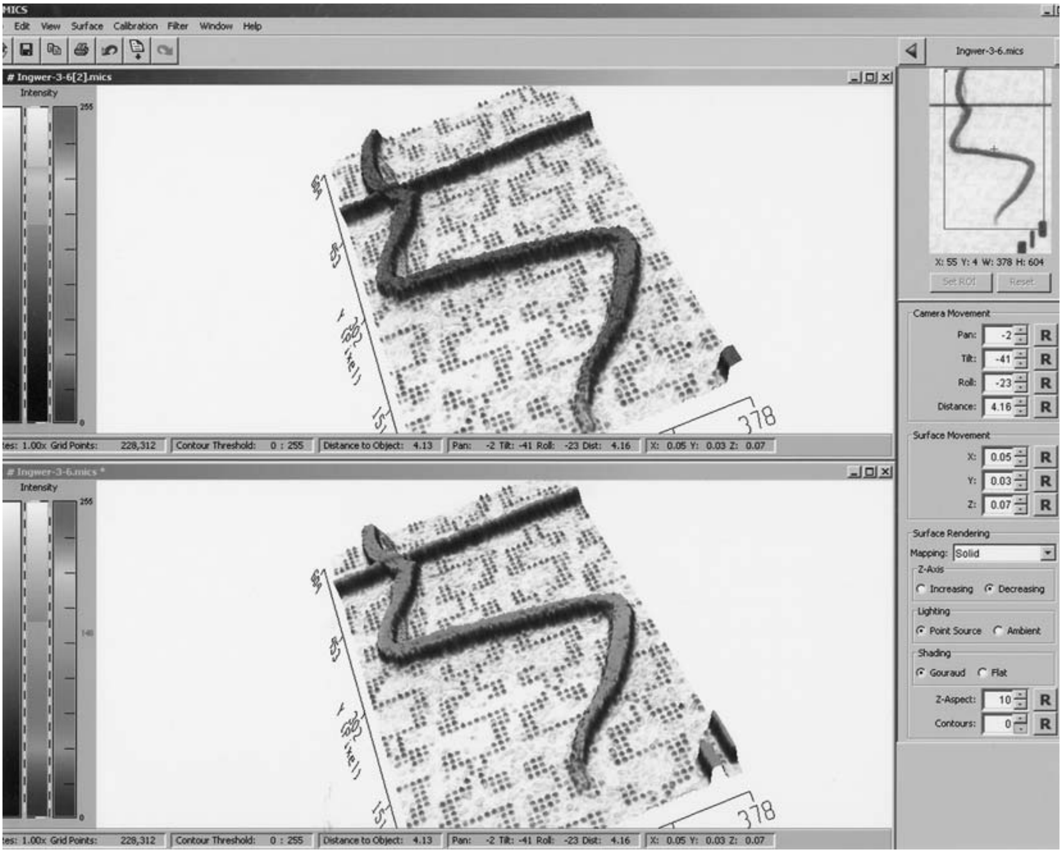

Figure 6.15 (A color version of this figure follows page 256.) Determining the order in which writing was produced in a document is sometimes critical in establishing the sequence of events. MICS (measurement of internal consistencies software) is a 3-D visualization tool that enhances the viewing of 2-D forensic images. *(Limbic Systems Inc. http://www.limbicsystemsinc.com.)*

Once the questioned documents have been discovered and received as evidence and have been properly handled and marked for identification, exemplar writings must be obtained. Exemplar writings are known specimens from the suspect and/or victim. They are extremely important and necessary to connect the suspect or victim to the document. Like the questioned document, exemplars must be properly identified and cared for. They should not be stapled, folded, rolled up, torn, punched, smeared with fingerprints, or otherwise damaged if they are to be acceptable as evidence. The purpose of exemplars is to give the examiner of the document in question a known specimen of the subject's writing, thus providing a source of the writer's individual writing habits and personal style characteristics.

There are two general types of handwriting exemplars: informal and formal. Informal exemplars are also referred to as nonrequest writing. These include the routine, normal course of business writings such as letters, application forms, business records, checks, etc. These documents are sometimes difficult to admit as evidence because their authenticity may be in question; however, they are the best examples of normal or natural handwriting. The subject prepares formal or "request writing" exemplars, usually at the request of the

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Figure 6.16 Before dying, a murder victim wrote the name of his assailant using his own blood. *(Metropolitan Police, Forensic Science Laboratory, London, England.)*

investigator. The format generally used is a handwriting exemplar card designated for that purpose. In addition to an exemplar card, fingerprint cards, booking slips, and, at times, tablet paper may be used to obtain miscellaneous or specific exemplar writing samples. The investigating officer will witness these writings.

The investigator should keep several helpful suggestions in mind when obtaining request exemplars. It is useful to study and become familiar with the questioned document, paying close attention to names, specific words, spellings, and other unusual features of the document. The writing instrument should be in good working order. It is preferable to use a ballpoint pen with blue or black ink. Felt tip pens and pencils should be avoided unless they are the type of writing instrument used in the questioned writing.

The writer should be provided with a comfortable writing area. Generally, exemplars written in the back seat of a police car en route to the station are worthless. The investigator should be present to observe the writing because he or she will be called upon in court to testify to this fact. Only like materials can be compared, that is, cursive writing must be compared with cursive, printing with printing, block letters with block letters, etc.

In addition to the exemplar card, specific writing specimens should be requested, including material contained in the questioned document. The wording of this questioned document should be dictated to the subject; the actual document should not be placed before the writer from which to copy. The writing instrument should be similar to the one

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used on the questioned document and the paper should be similar with respect to size, style, plain, ruled, etc. Several specimens should be obtained as long as the subject is willing to cooperate. If the writer is trying to disguise the writing, it is best to interrupt the periods of writing with conversation and fresh paper from time to time.

This procedure makes it difficult for the subject to maintain a consistent alteration of natural writing habits. In the event of wide variation or difference in the questioned writing and the exemplar, it may be useful to have the writer provide additional exemplars with the other hand.

Because narcotic addicts may show writing that varies from time to time, it may be necessary to obtain writing exemplars at various time intervals, sometimes several days apart. Handwriting reflects the effects of age, illness, injuries, and mental state. It is sometimes necessary for the investigator to obtain additional exemplars of the individual's writing by obtaining informal exemplars.

Identification of Human Remains

The fields of forensic anthropology and forensic odontology (dentistry) have made major contributions over the past decades in the identification of human remains. An in-depth examination is beyond the scope of this book; however, it is worthwhile for the investigator to be aware of some of the information that can be gleaned from semiskeletal remains. Forensic anthropology and odontology techniques are useful in cases in which normal methods of identification, such as facial photographs, fingerprints, physical description, blood grouping, markings on the body, etc., are not available for use. Such cases may involve discovery of buried bodies, badly burned bodies, skeletal remains, major disasters, and so on.

It is possible to determine two types of information from remains. The first is physical characteristics such as sex, ethnicity, approximate age, stature, certain disease states, old injuries, and the like. The second type, which is far more important for forensic purposes, is the actual identification of the individual. To accomplish this identification, adequate records indicating the deceased's physical characteristics must be available as a basis for comparison with the data collected from the examination.

Personal identification is one of the most important functions of an investigation. The identity of a living person at a crime scene establishes a strong link between the suspect and the crime. Likewise, the identity, or nonidentity, of a dead person sets the investigation in motion. Because relatives or acquaintances kill the majority of homicide victims, knowing the identity of the victim provides a starting point. From the identity, the character of the victim suggests possible suspects. Although not a responsibility of criminal investigations, the identity of noncriminal decedents enables the deceased person's relatives to collect insurance, settle estates, and provide for the welfare of dependents.

When police are called to a death investigation, relatives or acquaintances of the dead person or documents or possessions found on the body generally help to establish its identity. Caution should always be exercised in making a decision of identity merely because documents concerning a certain person are found on the body — such documents may be stolen, or false, or "planted." Furthermore, the body may be planted to permit someone to disappear. Substitute bodies have been discovered when the dead person's measurements did not agree with those of the alleged victim.

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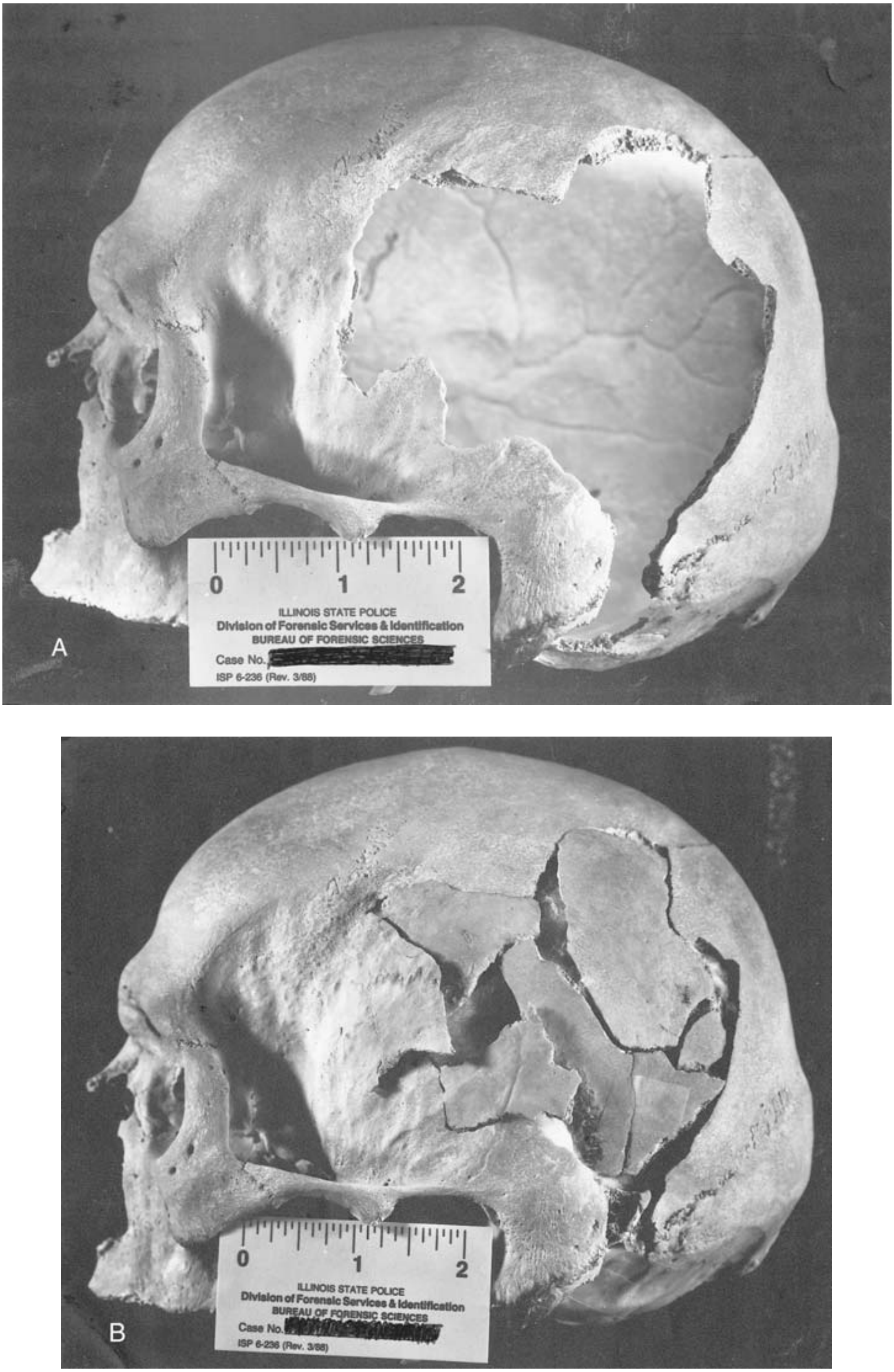

Figure 6.17 Suspected of being killed with a hammer blow on Christmas Eve, the victim's body surfaced in a nearby pond 9 months after the murder. The body had been tied to stones and cement rocks with a torn-up sheet. The laboratory was asked to determine if a certain hammer left any unique markings on the skull. The illustration shows (A) the skull and (B) the skull with bone fragments in place. In this case it was not possible to match the hammer to the damage. *(Illinois State Police, Bureau of Forensic Sciences.)*

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It cannot always be assumed that a relative or acquaintance is competent to identify the body. Instances have occurred in which, owing to the state of the body, even a spouse has made a mistake as to identity. It is necessary, therefore, to be careful in establishing a body's identity even though it can be determined with a fair degree of probability. These precautions consist of taking the fingerprints, photographing the body, noting the description (including the dental data), and examining and describing in detail the clothing and objects found on the body. DNA typing may sometimes also prove to be of assistance.

Sometimes, when the body of an unknown person is found, it is better to postpone a definite conclusion for a few days until the discovery has become generally known through publicity in local papers and/or the national press. Relatives or acquaintances of missing persons who read or hear of the discovery and communicate with the police identify most unknown bodies. The examination by the pathologist at the autopsy of the body will assist greatly in its description, particularly if the body is in an advanced state of decomposition. The pathologist will be able to give such details as apparent age, height, build, weight, and scars (including surgical scars).

However, if all this information, general examination, and publicity fail to establish the identity of the dead person and the body must be buried as that of an unknown individual, it is most important that everything, including the belongings of the deceased, that may be a guide to later identification be preserved for possible future use. Further samples should be taken of hair from the different parts of the body and blood group and dental data should be recorded.

In the identification of an unknown body, the police officer may need to work with bodies in varying states of decomposition. The most frequent case is that of a body found in water. These cases are considered the most repugnant and difficult. In warm weather, the body will swell up and the skin become almost black only a few days after death. More rarely, a mummified or petrified body is under inquiry. A dead body may become mummified when it lies in a dry place exposed to sun and air; the tissues do not putrefy but gradually dry up. Under certain conditions, a body can become petrified: the external parts are as if they are calcified due to formation of adipocere (also known as grave wax or mortuary fat) and the body resembles a marble statue. Formation of adipocere occurs chiefly in bodies that lie in a very damp place. It also may be necessary to identify a greatly changed or mutilated body or one of which only the skeleton or certain portions remain.

The deceased may be a murder victim. Therefore, before an attempt at identification, the investigation should be carefully planned. It must be decided how much of a search of pockets and other articles for identifying documents can be permitted without destroying other important evidence. It may be necessary to move the body or other form of remains to a mortuary where a careful examination can be conducted.

Generally, the first procedure is a preliminary investigation of the pockets of the clothes. If any documents or other material that can be a guide to identification are found, careful note should be taken with a view to publication. If this does not lead to any result, the work of identification is continued by taking photographs and fingerprints, preparing an accurate description, and making a detailed investigation and description of clothes and belongings, after which the discovery of the body may be published in a police bulletin for distribution to other agencies and the general press.

A form of identification work that requires exceptionally careful organization is the identification of victims of a catastrophe. The procedure for this type of identification is described later in this chapter.

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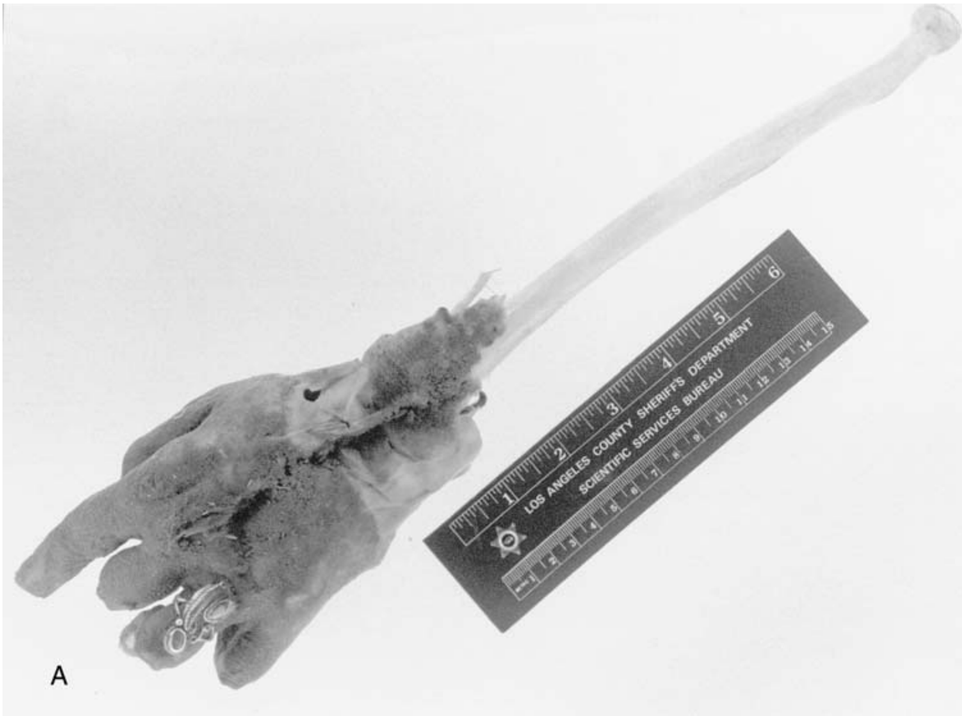

Figure 6.18 Unusual jewelry may play a part in identifying a deceased person. (A) A distinctive ring found on the hand of a badly decomposed body *(Los Angeles County Sheriff's Department)* or (B) a gold crucifix attached to the dentures of an unknown person may provide useful identifying information. *(George E. Burgman, DDS, forensic odontologist, Niagara Falls, Ontario, Canada.)*

Taking Fingerprints

Even if an individual is not on record in the fingerprint file, there is a good possibility of identifying the body through fingerprints. In many cases there is reason to assume that a body is that of a certain missing person, but even near relatives are unable to identify it because it has altered so much. Under these conditions, fingerprints are taken in order to compare them with latent prints in the home of the individual or at the place of employment. This type of investigation often gives a positive result.

There is no special difficulty in taking fingerprints from a body after the rigidity has relaxed or when rigidity has only developed to a small extent and the body has not undergone any considerable change. If fingers are rigid, the joints should be bent several times until they are sufficiently flexible. The tips of the fingers are then inked, using a rubber roller and printing ink or commercially available inking materials, and the prints are taken on small pieces of thin card that are pressed against the papillary pattern on the tip of the finger. The finger should not be rolled against the card because the print will inevitably suffer from slipping. With some practice, the card may instead be rolled around the fingertip for satisfactory results.

A number of prints of the same finger are taken so that the best results can be selected. When a sufficient number of prints have been taken from one finger, each piece of card is marked to show to which finger it corresponds. When prints have been taken from all the fingers, the best are selected from each and stuck onto the respective sections of a

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Figure 6.18 (continued)

fingerprint card. It is important to be careful not to get the fingers mixed up when sticking on the prints; if prints of two fingers do happen to get interchanged, then a search in the register will probably be fruitless. It is best to make up two cards, one to be sent to the state or federal file and the other filed with the records. If suitable thin cards cannot be obtained, ordinary glazed writing paper can be used. In such a case, using a piece of wood or sheet metal cut to a form fitting the finger facilitates taking the prints. The pieces of paper are placed on this and fixed or held fast on it when the prints are taken.

Once the rigidity of the body is complete it is difficult to take fingerprints because the fingers are bent toward the palm of the hand and are so stiff that they cannot be straightened. There is no point in attempting to extend such a finger. In this case, it may be necessary to cut certain tendons in the fingers so that they can be straightened. Certainly, this method is quite effective, but it is not necessary to go to this extreme. It is simpler to bend the hand backward at the wrist to a right or acute angle to the forearm, whereby the fingers will be straightened. It is then possible to hold a finger firmly and lift it up to make the print, with the bend at the wrist becoming slightly reduced. If this method is difficult, then the wrist is bent down again and the required finger is pressed down toward the palm, which makes it accessible from below.

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Difficulty is often experienced when the body is considerably decomposed. The changes in the fingers consist either of their drying up and becoming horny and hard or of the tissues becoming loose and filled with liquid and the epidermis becoming fragile and puckered ("dishpan" hands). The first generally occurs when the body has been in a dry place and the second when it has been in water.

When the fingers have shriveled and dried up, fingerprints cannot be taken by the methods just described. Other methods must be employed. The prints may be read directly from the fingers and classified without taking impressions. It is necessary to be very careful and, if possible, perform ridge counting and ridge tracing also on those fingers not required for the classification formulae. A selection is then made of the finger or fingers most suitable for recording with printing ink. When this has been done, a search can be made in the fingerprint file. Only persons with considerable experience in fingerprint classification can use this method. When reading a pattern directly from a finger it must be remembered that the print is seen reversed, as in a mirror.

Another method to record fingerprints from deceased persons is by photography. This method is rather tedious and difficult to carry out. If the fingers are stiff and bent, it is necessary to photograph each finger separately.

Frequently, fingertips are so dried out and wrinkled that the friction ridge pattern cannot be read because important parts are concealed in hard folds of the skin. The pattern may be read by removing the fingers from the hand and softening the skin. The pathologist should have an opportunity to view the deceased before this step is taken. The fingers should be cut at the second or middle joint and placed in individual labeled bottles, each bottle noting the hand and finger. Only the pathologist or other competent person should perform this operation. The investigator should be present to verify that the fingers do not get mixed up.

The simplest method for softening dried fingers is to let them soak in a water solution containing Eastman Kodak Photo-Flo 200® or diluted liquid fabric softener[4] for 1 or 2 days, after which they are carefully kneaded until they are sufficiently soft for a print to be taken with the aid of printing ink. If difficulties are still encountered, the fingers must be photographed.

Taking fingerprints from a corpse removed from water is difficult because of changes in the body. In general, changes may be divided into three stages: (1) the epidermis of the fingertips becomes loose and coarsely ridged; (2) the epidermis is loose everywhere and can be removed; and (3) the epidermis is completely missing.

In the first stage, the fingertips must be washed and dried, preferably with cotton or a soft towel. This operation must be done with care and without rubbing so that the skin is not torn off. Fingerprints are then taken in the usual way.

When the skin is wrinkled and granulated, water must first be injected into the upper joint of the finger so that the creases and granulations are smoothed out. For this purpose, a 10-ml hypodermic syringe with a fine needle is used. The needle is inserted approximately at the center of the inside of the middle joint and brought close to the bone in the upper joint, after which water is injected until the skin appears hard and tense. The needle must not be allowed to come too near the skin because the pressure might be sufficient to break the skin, nor should it be put in or too near the outer joint — the return path would be so short that the water would run out again. After the needle has been removed, the print

[4] Downy® fabric softener works well for this purpose.

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is taken in the usual way. In earlier technical literature, an injection of glycerin, paraffin, or even melted tallow was recommended. However, a properly performed injection with water gives better results and is easier to perform.

In the second stage, when the epidermis has loosened, it is easier to take fingerprints. The loose skin (finger stalls) of the tip is pulled or cut off from the fingertips; the skin from each finger is placed in a labeled test tube filled with water. The finger stalls should not be put in an envelope or other paper wrapping because after a time they will dry up and stick to the paper. When they have been removed this way, the finger stalls may be sent to the fingerprint unit for examination.

For easier handling and photographing, the best procedure is to place the skin from each finger separately between two glass slides. To do this, the fingerprint pattern is cut out of the finger stalls. Because the cutout pieces of skin are then convex, they easily split when flattened between the glass slides. This splitting is unavoidable; therefore it is necessary to make cuts in the edges so that the splits do not occur in parts of the fingerprint pattern needed for the purpose of classification. When placing them between the glass slides, a small piece of paper or card with the name of the finger is placed near the top of the sample to indicate that the print is being viewed from the correct side. There is not much risk of any such piece of skin being the wrong side because the inside is lighter, smoother, and glossier than the outside. If, however, in a particular case some doubt exists as to which is the inside, taking the piece of skin out and viewing it can determine which side is concave. The glass slides should be taped together. The fingerprint patterns should be photographed by transmitted light; the lines will show up very distinctly.

Prints may also be taken with the aid of printing ink. After careful cleaning and drying, the pattern area is coated with printing ink in the usual way and pressed against a piece of paper. This method is difficult to carry out because the skin is generally so fragile that the print can be destroyed by the slightest carelessness. Occasionally, the finger stalls are so strong that they can be picked up on a finger and the print can be taken as it would be from a living person. However, only in rare cases is the skin on all 10 digits in such good condition that this method can be used.

It often happens that large portions of the epidermis become loose, but small parts remain so firmly attached that the finger stalls cannot be removed whole. Careful scraping of the attached tissues may loosen the tips in a comparatively whole condition. If this is impossible, the part of the underlying tissues to which the finger stalls are attached is cut off, and the whole piece is mounted on a piece of plasticine. The fingerprint can then be taken with printing ink or photographed.

It is far more difficult to take a fingerprint from a dead person when the epidermis of the fingers has fallen away and cannot be found. This occurs generally with bodies that have been in water for a long period of time. Sometimes it is possible to make out the fingerprint pattern in the remaining underskin. Only rarely is it possible to take these fingerprints with printing ink, due to very low ridges in the pattern. The only possible method is to photograph the pattern. In general, however, it can be assumed that the fingerprint pattern will have disappeared entirely because of loosening of the skin.

It is difficult to take a palm print from a dead body, even in a case where the body has undergone little or no change. There is hardly any hope of taking a complete palm print and it is therefore necessary to take portions of the print on small pieces of paper or card. To simplify the identification of these prints, each piece of paper should have outlined on it a hand on which the part corresponding to the palm print is marked. In taking finger

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and palm prints from bodies, printing ink is the best medium because the impressions can be mounted directly onto a fingerprint card or other suitable form. These forms can later be filed with other cards. However, an alternate method may be used that employs black fingerprint powder. In some cases, the results of this method may be superior to those with printing ink. The finger or palm is lightly coated with the black powder, using a brush. The impression is obtained by lifting transparent fingerprint tape. The pieces of tape are then mounted directly onto a fingerprint card or on paper cut up into squares for attachment to the card.

In the case of palms, pieces of tape should be laid lengthwise over the whole palm area and removed one at a time. The pieces are then mounted onto a card or paper. This method is somewhat more difficult than the inking method, but it is superior in that a full impression is obtained. A condition for successful lifting is that two persons are available: one to hold the hand and one to manipulate the tape.

Photographing

In photographing an unknown body, full-face and right-profile face photos are always taken. If necessary, further pictures should be taken, including a whole view, left profile — especially with a view to identification from the ears — and detailed photos of scars, injuries, teeth, tattoos, clothes, etc. It is good practice to ensure that an unidentified body is not buried before it is photographed; however, it is important to photograph the body before putrefaction sets in and swells or discolors the features. With regard to a body that has undergone some degree of change, although a photograph of the face may be considered quite meaningless, it should still be done. It should also be remembered that the individual may be identified after burial and that the relatives may ask to see the photograph of the face. In taking a full-face picture, the body should be laid on its back with the face turned upward.

When the body is in a mortuary, a wooden rack or other structure that is generally placed under the head should be removed for the photograph. The lower jaw has a tendency to drop, causing the mouth to open, so it is recommended to prop the chin up with a peg or other object that will not be too conspicuous in the photograph. The camera is placed vertically above the face. The color of background material should be chosen so that the outer contour of the head is well defined against it. Often the simplest way is to spread a towel under the head. When profile portraits are taken, the body should be raised so that the camera can be placed at the side of the head. A suitable background is also required for this exposure so that the profile shows up distinctly. The head should not be turned to one side to make it easier to photograph because this might cause considerable alteration in appearance owing to the position of the camera.

In photographing whole-face pictures, the camera is placed high above the body. If this is not possible because of a low roof, then the body can be turned a little to one side, but the procedure must be well thought-out to avoid the possibility of blood running down or other conditions of the body being altered. Under no circumstances should the body be tied or suspended in a leaning position. In photographing scars, injuries, tattoos, and details of clothing, a measuring tape or ruler should always be placed on or by the side of the object to provide scale.

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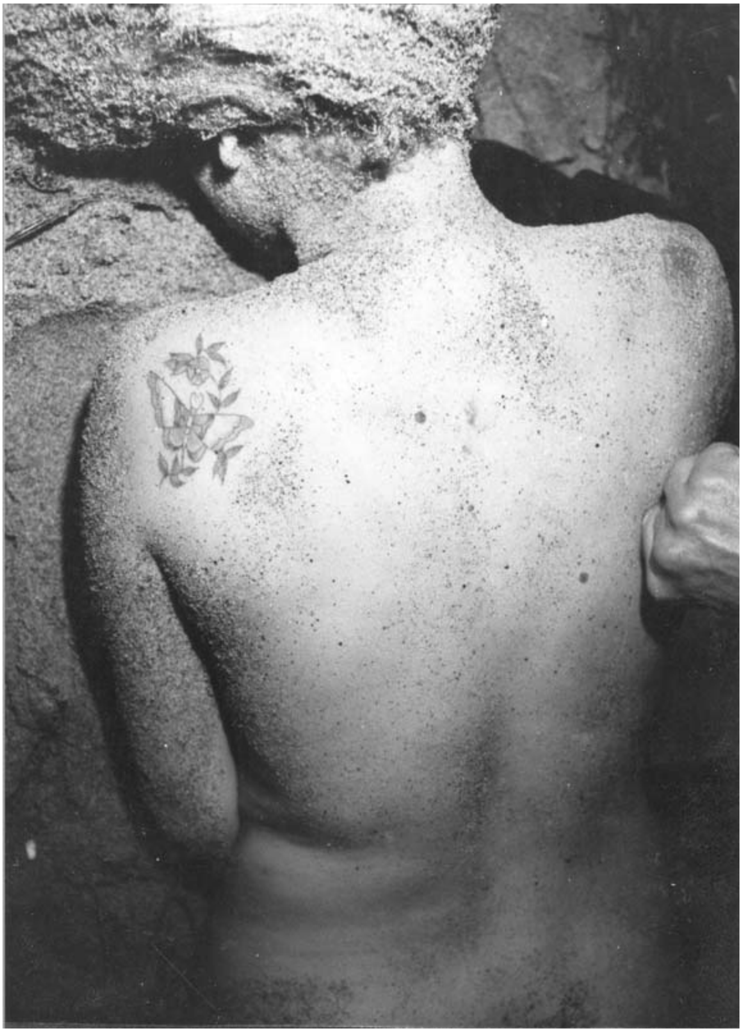

Figure 6.19 The body of a nude female was found on a beach in Los Angeles County. A butterfly was tattooed on the left shoulder. *(Los Angeles County Sheriff's Department.)*

Photographs are best taken using color film. However, in certain instances in which tattoos or other marks present on the body are poorly contrasted, appropriate filters or black and white photography may be helpful.

Even at such an early stage when the changes in the body are limited to rigidity and lividity stains, it may be difficult to distinguish scars, strawberry marks, and birthmarks from livid stains, discolorations of the skin, and wrinkles. The further the deterioration has proceeded, the greater the difficulties. Blue tattooing can be barely perceptible when the skin becomes dark colored and blistered. Under such conditions, the police officer must not rely on personal judgment, but must consult the pathologist. Any special characteristics are described in essentially the same way as for living persons, except in one respect. In the case of a description of a living person with a large number of tattoos, only those that are characteristic or unusual (names, dates, emblems, etc.) are described.[5] With unknown bodies, however, all tattoos should be described, including the most common

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Figure 6.20 Using reflected infrared photography, a photograph of a tattoo was made from a badly decomposed body. (A) The tattoo depicts a black panther encircled by a snake. A police artist copied the tattoo and it was published in newspapers (B). *(State Forensic Science Laboratory, Melbourne, Australia.)*

types. It is very important that these and other special characteristics be described accurately in a recognized manner with respect to kind, form, size, and position.

Ultraviolet photography and ultraviolet video imaging techniques are useful methods for studying and recording injuries on human skin, such as bite marks and ligature marks, using fluorescent UV photography, reflective long-wavelength UV photography, and short-wavelength UV photography. Taking UV photographs is a cumbersome procedure in that it is difficult to focus UV images because they cannot be seen. A new procedure involves using an ultraviolet image intensifier. One unit marketed by Hamamatsu has the appearance of an infrared night scope and can be used coupled to a camera or video unit, or by viewing through an eyepiece in the unit. It allows for quick and easy viewing of trauma and even some latent fingerprints on surfaces using ultraviolet lighting.

Many people are x-rayed for the purpose of diagnosing medical conditions or for detecting dental caries. These films are often retained in medical files for many years. Before an unknown body is autopsied or buried, dental and body x-rays should be taken. They

[5] Asian gang members often have elaborate tattooing, frequently depicting dragons and other animals. Such tattooing on an Asian decedent may suggest gang membership.

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Churcn-
grants 'i

FEDERAL GOVERNMENT aid was a religious schools — and it was illega yesterday.

Mr Neil McPhee, QC, submitted to Mr Justice Murphy that federal aid to religious schools was prohibited by the Constitution.

He was opening a case in which the Council for the Defence of Government Schools, and others' are challenging the validity of federal aid to religious schools.

Mr McPhee said Section 116 of the Constitution prohibited the Commonwealth from establishing any religion, imposing religious observances, interfering with religious practice or subjecting anyone to religious tests.

It also precluded the Commonwealth from recognising or helping any religion.

This meant citizens would not be subjected "taxwise, financially or otherwise to the pressures which flow from any attempt by the Commonwealth to support a religion or any group of religions."

But it was clear from examining the income sources of religious schools that federal aid was a big factor in maintaining the reli school system.

In 1977, aid t government schoo been $308 per while aid to Gove schools had been student.

Mr McPhee sa case was not an on any particula gion, but most e would relate to t man Catholic Chu

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THE Australian ask the Premier tion on journa and interstate daily press con

This follows the yesterday of a m press conference lines by Mr principal press se Mr Richard Thom

The memo said accreditation wo

Tattoo clue on body

POLICE are hoping this tattoo will help identify a man whose body was found in the Yarra River last month.

The body was found at Templestowe on February 11.

Poilce believe it had been in the river between two and four months and may have drifted some distance downstream.

The large tattoo on the upper right arm is the only distinguishing feature on the body.

It depicts a black panther encircled by a green snake with yellow and red markings.

Police believe the dead man was about 40 years of age and was wearing blue denim jeans, a green roll-neck short sleeved jumper, brown shoes and pink socks.

Anybody with information is asked to contact Doncaster CIB on 841-0222.

Strikers go ba

THOUSANDS of airport workers will be back on the job today after ending their 20-day strike.

About 1500 workers yesterday voted overwhelmingly to accept pay rises granted in the Arbitration Commission last Friday.

The rises of be and $14 will b dated to Decen

Sydney airport will meet at the Oval this morni meeting is exp follow the Melbo cision by accepti

(B)

Figure 6.20 (continued)

not only provide a means of definite identification, but might also provide information as to the cause of death.

Marks of Trades or Occupations

Although less common today than in the past, marks and calluses on the hands associated with specific trades may be instructive. When examining victims and suspects, consider the following:

- Clerk, draftsman — hardening of the last joint of the right middle finger at the point where the pen rests when writing or drawing; draftsman: hardening on the part or the ball of the right little finger that lies nearest the wrist

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Figure 6.21 (A color version of this figure follows page 256.) Ultraviolet photography is useful in visualizing ligature marks as depicted in this case, one of the Hillside Strangler murders in Los Angeles. *(Los Angeles County Sheriff's Department.)*

- Baker — hardening on thumb and index fingers of both hands from handling the edges of hot pans and plates
- Engraver, jeweler — wear on nail of right thumb
- Tailor, dressmaker — marks and scars of needle punctures in the tip of left index finger
- Shoemaker, upholsterer — round hollows in front teeth from biting the thread; shoemaker: wear on left thumbnail
- Glazier — hardening between middle and index fingers, arising from handle of diamond being held between these fingers
- Dyer, photographer, chemist — nails dry, brittle, and often discolored

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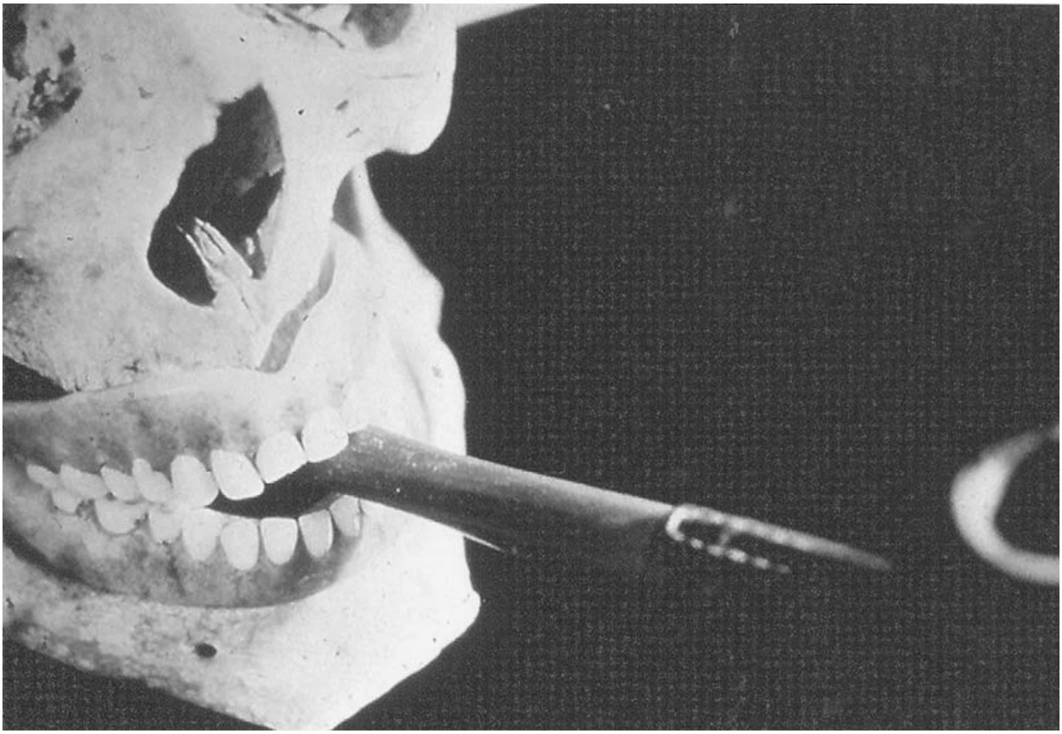

Figure 6.22 (A color version of this figure follows page 256.) This set of complete dentures shows unusual wear on the front teeth. Constant pipe smoking can produce severe wear on dentures and on natural teeth. *(C. Michael Bowers, DDS, JD, Ventura, California.)*

- Butcher — calluses and hardening on inner joints of fingers and on neighboring parts of palm of the hand that holds knives
- Bricklayer, stonemason — hardening of right hand from grip around trowel or hammer; skin of left hand worn very thin from holding bricks or stone
- Carpenter, joiner — hardening in ball of thumb of right hand from grip on plane; unusual number of injuries and scars on left index finger
- Painter — calluses and hardening between right index and middle fingers from grip on handle of brush

If evidence of repetitive operations is observed, it should be noted, sketched, and photographed. It may take imagination, ingenuity, and some practical research in order to connect these calluses to a specific occupation, hobby, or sport.

Making a Description

Making a satisfactory description of a dead body takes time and is often difficult, especially if the body has begun to decompose. In compiling descriptions, it is therefore best to avoid using too definite an expression when describing details for which there is some doubt as to the most suitable choice of words. In case of difficulty, the pathologist should be consulted. The body may conveniently be described in the following order: estimated age,

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length, build, shape of face, neck, hair, beard, or mustache, forehead, eyes, eyebrows, nose, base of nose, mouth, teeth, chin, ears, hands, feet, and any outstanding characteristics.

If the body has undergone a certain amount of change it is often nearly impossible to decide the age; even a trained pathologist will often avoid making any definite statement. In many cases, the age can be determined only by postmortem examination.

The length of the body is measured with the body stretched out on its back. The measurement is taken from the heel to the crown of the head. It is often difficult to describe the build. In the case of a swollen body that has been submerged, there may be the temptation to write "well nourished" or "stocky" in the notes, which may be an error. The facial appearance can be described to some degree, but a complete description of the face cannot be specified when a body has undergone considerable change. The color of the hair also may change some time after death. When a body has been in dry earth or in a hot, dry location, the hair may become reddish; however, with a submerged body, hair color may not appreciably change.

In describing the hair, note if it has been well cared for, how it is parted, etc. Hair samples should be taken from bodies that cannot be identified. DNA typing may be possible and compared with hair found in the home or workplace of a missing person. In describing facial hair, avoid using a term such as "unshaven." That description may be inaccurate as the stubble on the face arises from the hair roots on the face. Hair roots, which lie at an angle to the skin, straighten up after death because of drying and shrinking of the skin — hence the myth that hair and beards grow after death.

It is often difficult to judge the eye color of a dead person because the eyes undergo considerable change after death. Attention should also be given to artificial eyes. The forehead is not likely to change much with respect to form. It is difficult to judge the form and size of the nose because it may swell considerably. On a body that has not undergone any considerable change, the profile of the nose may be altered considerably due to shrinking of the tissues in the tip of the nose. As a result, a living person's nose that is concave may become straight after death, and a straight nose may become convex. It is usually impossible to decide the size of the mouth because the lips undergo great changes in the very early stages of decomposition.

The size and form of the ears may undergo only minor changes. In cases where the face and body become completely unrecognizable, the ears may look relatively normal. Therefore, it is important to photograph both ears so that they may be compared with a missing-person photograph at some future date.

When examining the hands, note the condition of the fingernails. If applicable, take nail scrapings. Debris under the nails sometimes yields pertinent information. When an unknown body is found without shoes, measure the foot length and width to estimate the approximate shoe size.

The pathologist should take a blood sample from the body. Comparisons with blood found at the crime scene or on the perpetrator may be important. In missing person cases, it may be possible to do reverse paternity typing to demonstrate that the victim was related to someone. Although the individual may not be identified by blood type in all cases, a genetic profile may lead to a family connection or to excluding possible identities. Typing of putrefied blood or tissue may be difficult but breakthroughs in forensic biology are improving the chances of identifying missing persons through new procedures.

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The Deceased's Clothing

The outer clothing is described first, including accurate indications of the type of material, quality, color, buttons, damage and, if possible, how the damage is thought to have occurred, stains of dust and dirt, etc. A preliminary examination is made of the pockets and other areas of the clothing, e.g., between the clothing and the lining where objects may be found that can be a guide for identification. Garments should be removed one at a time and placed on clean paper and allowed to air-dry at room temperature. If at all possible, the clothing should not be removed by cutting or tearing, but should be carefully removed in the usual manner. The person undressing the corpse should be aware that microscopic trace evidence may be present on the clothing, and appropriate care should be exercised so that no useful evidence is lost. If the clothing must be cut from the body, care must be taken to avoid cutting through areas with bullet holes or knife cuts because these areas will be examined in depth later.

After the garment is removed and has been air-dried, it should be packaged and sent to the crime laboratory for examination for debris, trace evidence, and marks of identification such as laundry marks, monograms, manufacturer's markings, and dry cleaning tags.

Shoe size, color, make, and style should be noted. If the size cannot be determined, it is possible to approximate the shoe size by the length of the shoe. Repairs, degree of wear, defects, etc. may also be used as a possible means of identification. Shoes should be submitted to the laboratory for examination for the presence of soil, debris, and other trace evidence that may be helpful in determining identity.

Garments should not be laundered until after the clothing has been carefully examined for trace material and photographed. After these procedures, the garments can be laundered so that clear identification photographs can be made of the clothing and laundry marks can be visible.

Articles of clothing should be repackaged following examination at the laboratory and retained until after adjudication of the case. Under no circumstance should these or any other evidence be destroyed until after all legal proceedings have been completed. This allows the investigator to reexamine the clothing at a later time if new questions arise.

Laundry Marks

In searching for laundry marks on clothing, it should be noted that they may be invisible. Many large laundries now stamp all incoming laundry with a colorless dye imperceptible to the unaided eye, but which fluoresces strongly in ultraviolet light. The mark usually comprises the identification mark of the laundry and the number given to the customer. The identification mark sometimes consists of the first letters of the firm's name. The number of the customer is registered with the laundry. The marks are quite durable and remain even after many washings. When the laundry marks the garment, a search is first made for old laundry marks, which are crossed out with invisible ink before the new mark is put on. In this way, a garment may have several laundry marks, which greatly facilitates identification.

It is common practice in the cleaning and laundry industries to identify garments with a paper tag clipped to the article. Unless this tag is attached in an obscure place, the customer usually removes it before wearing the garment.

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A good lead for identification can be obtained from monograms, manufacturer's marks, firm's marks, stamp numbers, embroidered initials, and markings made with marking ink. In the case of more valuable garments such as fur coats, overcoats, and suits, it is important to look for marks or alterations often placed on parts turned toward the inside with the idea that the garment may be stolen and that the thief would remove the usual marks. Such identification marks may consist of seams sewn with a different thread, small cuts or pieces cut out of the cloth or lining, threads sewn in, etc.

Watchmaker's Marks

If a watch is found on an unknown dead body, it should be examined for any marks or figures that might aid in the identification. Usually the serial number of a watch is stamped inside the case. Certain watchmakers mark their watches with letters or symbols that indicate their watchmaker's society, together with their membership number. When a sale is made, it may be recommended to the customer to take out insurance on the watch, in which case the purchaser's name and the serial number on the watch are registered by the watchmaker. Some watchmakers mark the date of sale on the inside of the case.

When a watch is taken in for repair, it is customary for the watchmaker to scratch the inside of the case with certain letters or marks and figures that are partly special marks of the individual watchmaker and partly a repair number. The latter is recorded together with the serial number of the watch, name of the owner, and type of repair. The watchmaker's own mark generally consists of one or more initials, but may also be a monogram, Greek letters, or other characters, shorthand signs, punctuation marks, private marks, lines, figures, or mathematical signs. Investigators should contact the American Watchmakers–Clockmakers Institute[6] at 701 Enterprise Dr., Harrison, Ohio, 45030-1696 for assistance.

Jewelry

Finger rings usually remain on a body even when it has decomposed to a considerable extent; therefore, they can be a means of identification. Inscriptions may often be found inside engagement, wedding, and other commemorative rings, while signet rings may carry initials, insignia, seals, crests, or other distinctive markings. In a number of countries, graduates of universities wear special rings. Orders, societies, and associations may use rings as marks of membership.

Systems are available for the identification of precious gems. These systems are based upon macroscopic and microscopic imperfections in any gemstone that are not likely to be found in their entire combination in any similar gem.[7] All jewelry should be photographed.

Eyeglasses

Eyeglasses discovered on or near a dead body may provide a means of identification. If the name of the optometrist is on the eyeglass case, it may be possible to determine the victim's name from the doctor's records. Even if the identity of an individual cannot be determined from a prescription, eyeglasses may be useful. Friends or relatives of the victim may be able to identify the eyeglasses as similar to those worn by the victim.

[6] http://www.awi-net.org/
[7] The Gemological Institute of America, http://www.gia.edu/, may provide assistance with precious gems.

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Teeth

Information of special value for identification can be obtained from investigating the teeth of a dead person because they are often characteristic in many respects. This applies not only to the appearance of the dead person who has not altered to any appreciable extent, but also to greatly decomposed corpses, badly mutilated victims of airplane accidents, explosions and catastrophes, and burned bodies. The teeth are very resistant to the normal changes of decomposition as well as to fire and chemicals.

Assisted if necessary by a dentist, the pathologist examines the teeth of an unknown dead person for identification purposes. The police officer in charge of the case will decide, according to its importance, to what degree it is necessary to have detailed information in connection with a particular case. In some cases, an abundance of other information will not necessitate basing an actual identity on the teeth alone.

When the teeth are examined, attention is always directed to the changes or injuries in the face of the dead person that may possibly interfere with the subsequent postmortem examination or identification. If a body is altered considerably, the tissues of the face may be missing or may fall apart if the lower jaw is moved out of its position. In such a case, photographing and examining the body should be done first. If for any reason a police officer must examine the teeth of a body before the arrival of the pathologist, he should do so in such a way that no marks of the flow of blood or injuries in the face are aggravated or changed; particularly, the position of any object in the mouth should not be changed. If there is any danger of anything of this kind occurring, the examination of the teeth must wait until the pathologist deals with the body.

The first note to make in connection with the teeth is how many are present. A note should be made as to which teeth are missing in the upper and the lower jaws. This may be done by making a sketch of the teeth of each jaw. Special forms, sometimes used for this purpose, greatly facilitate the work. These sketches or forms are marked with the position and size of any visible damage resulting from decay (caries) and pieces broken away, cracks, missing fillings, jackets and other crowns, bridge work, root canals, etc. The material used in crowns, fillings, and the like is also noted. Sometimes entire gold crowns melt when teeth are exposed to high temperatures from fire. This is apparent from the amalgam filling running out and around the mouth.

Complete or partial dentures should be kept because the material used in them may possibly be a guide for identification. Dentures may have some identification inscribed on or attached to them. It may be the inmate number, service serial number, doctor's identification, or patient's name. A study of the style of the inscription will give some indication of the probable source.

Furthermore, all characteristics of the teeth should be carefully noted. Teeth can be very light (white) or dark (brown); the teeth of the upper and/or lower jaw may be directed inward or outward and the teeth may be widely spaced, close together, or wedged in against one another. Exceptionally large spaces may be found between the middle front teeth (central incisors); the central teeth in the upper jaw may be exceptionally powerful (wide); the front teeth in the upper or lower jaw may have noticeably smooth, uneven, or inclined cutting surfaces. Attention should also be given to the bite, that is, the relation between the teeth of the upper and lower jaw when they come together. In a normal bite, the lower edge of the front teeth of the upper jaw fits outside the front teeth of the lower jaw, and the outer chewing surfaces of the upper molars bite somewhat outside the corresponding

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teeth in the lower jaw. This is called normal occlusion. However, the bite may be such that the front teeth of the upper jaw are quite appreciably outside or inside the front teeth of the lower jaw, or that the front and canine teeth in the upper jaw are alternately in front of and behind the corresponding teeth of the lower jaw.

When examining teeth, the assistance of a dentist should be obtained if possible. This is especially important for root fillings and other work that may be difficult for the untrained individual to detect. A small mirror is valuable help in the examination. If dental work is apparent, identification is possible through the dentist who treated the patient. Dentists keep records of the work on their patients. In an important case, an x-ray examination should be made. Any roots, root fillings, or the like remaining in the jawbones may have a characteristic appearance; an x-ray photograph may agree exactly with one that a dentist has kept.

If teeth are entirely or partially missing from the body, there is reason to suspect that the individual used a full or partial denture. The latter may be found at the house of a missing person or with relatives, and it can then be fitted in the mouth of the dead person, whereby identity or nonidentity can be proved.

In addition to identification of a victim by means of x-rays of teeth compared with dental records, other useful information can be developed through dental examination. These data are useful in identifying the remains of a decomposed or skeletal body.

Age can be determined through dental examination. The ages for eruption of deciduous (baby) teeth and permanent teeth are fairly well established. X-rays of the jaw and examination of the mouth allow the forensic odontologist to make an age determination of the deceased. Habits or occupation may also be deduced through a dental examination. For example, a pipe smoker may have stained and worn surfaces on the teeth and a tailor may have a groove on the surface of two opposing teeth caused by biting thread. Such characteristics, like those discussed earlier with regard to skin calluses on hands, may prove useful in certain cases.

The arrangement of teeth in the mouth can be useful for identification. Thus, crooked or buckteeth of a deceased may be used as a means of elimination or identification of a particular person. Similarly, disease states, missing teeth, chipped or broken teeth, etc. are helpful for identification.

Facial Reconstruction

Occasionally, the police investigator will want to obtain a photograph of the reconstructed face of a mutilated victim. In instances where parts of the face are missing, it is possible to reconstruct the area with various types of mortuary supply materials and cosmetics to a point where a reasonable likeness of the deceased can be made. The procedure requires a fair amount of skill and workmanship, but is possible in instances where a reconstruction for identification is needed.

Determination of Gender

For the determination of gender, the skeletal characteristics are as follows:

Pelvis. Size and form are different for men and women. The pre-auricular notch and pubic curve are especially significant, and even small fragments can make a determination of gender possible.

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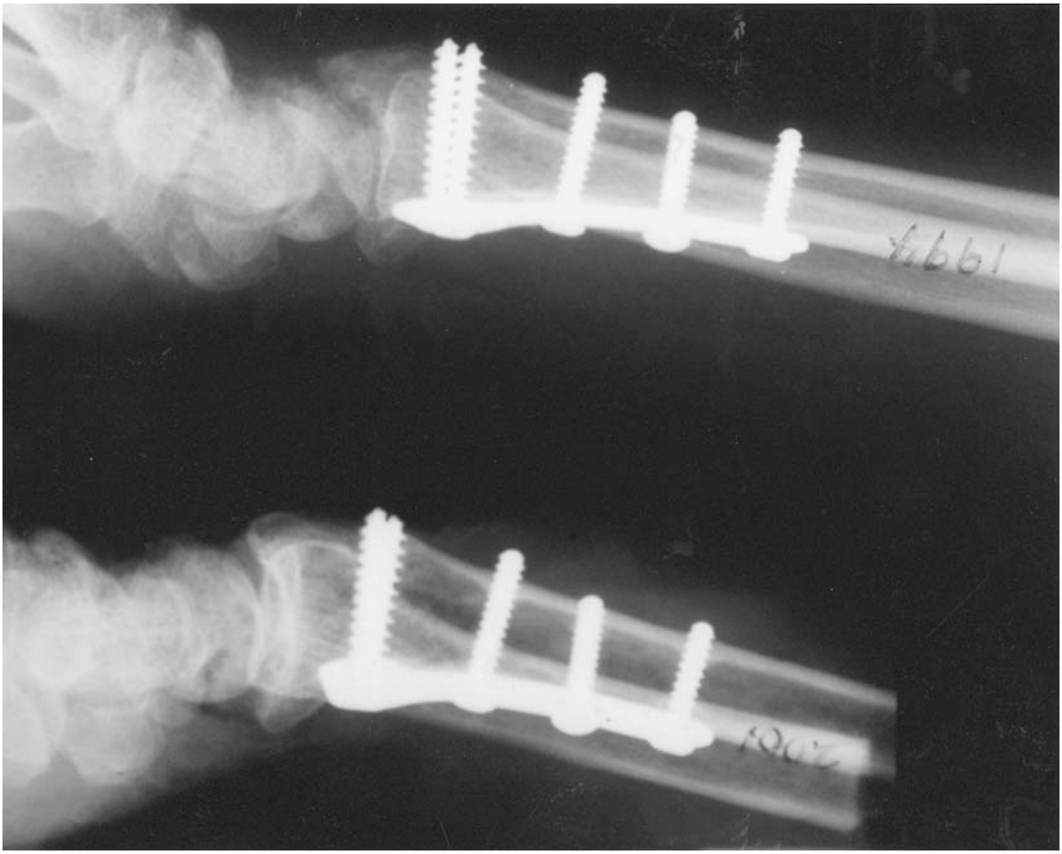

Figure 6.23 (A color version of this figure follows page 256.) In addition to dental x-rays, x-rays of the entire body may be useful. Police investigators obtained medical records of the person reported missing. The records indicated the person had been treated for a fractured forearm. A stainless steel fixation device was placed with screws and remained in place. The autopsy radiographs (x-rays) determined the presence of a similar device in the same forearm of the human remains. The concordance of shape and materials of this device is obvious as seen in both the radiographs. *(C. Michael Bowers, DDS, JD, Ventura, California.)*

Cranium. The walls of the cranium are normally thinner in men than in women. The angle of the root of the nose where it comes out from the forehead (frontal nose angle) is more pronounced in a man. The curve of the eyebrows is generally more rounded in a man than in a woman.

Head of joint of upper arm. This is generally larger in a man than in a woman. Moreover, the size of the head of the joint shrinks only slightly under the action of fire.

Breastbone, thighbone, and shinbones. Both size and form are significant for determination of gender.

Skeleton. The entire female skeleton, with the exception of the pelvis, is in general more lightly constructed than that of a man.

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Teeth. In the case of the remains of a child, an important point for the determination of gender is the uninjured crown of the first permanent incisor of the upper jaw. In certain cases, these can show the gender according to whether their width is especially great (boy) or small (girl).

Organs. The uterus or the prostate gland will indicate gender. However, a uterus exposed to decay can become very fragile, so great care should be taken.

Determination of Age

Teeth are especially significant in the determination of age, which is possible even when only one tooth is available; however, it is necessary to allow for a certain percentage of error in this case (according to some authorities, about 15 to 20%). If a number of teeth are found, the reliability of the determination is increased. The determination of age from teeth is based on the changes the teeth undergo with aging. These changes are listed below:

1. Wearing down of chewing surfaces (abrasions)
2. Loosening (paradentosis), detected from changes in the attachment of the roots
3. Formation of secondary dentin inside the pulp cavities (can also be formed as reaction to disease of the teeth)
4. Deposition of cement on and around points of the roots
5. Degree of transparency of lowest parts of roots (root transparency)
6. Corrosion of root points (root resorption)
7. Closing of root openings: until the teeth are completely formed, the size of the root openings is in direct relation to the age, so this is of special importance for young individuals

If the body has been completely burned, the crowns of grown-out teeth break up but the roots often remain whole. If the teeth of a child or young person have not erupted, they do not get broken up. The discovery of teeth that have not erupted or of remains of deciduous teeth thus gives a direct indication of age. When more than one tooth is found, it is important to determine whether the remains come from one or more individuals. Such an investigation can often be carried out with good results. It is based on microscopic appearance of the lines in the dentin that are characteristic of individuals and thus it is possible to determine whether or not teeth come from the same individual.

The roof of the cranium gives information that is especially valuable for the determination of the age of an individual; the sutures (ossification lines) are extremely significant. With newborn babies and children up to 3 years of age, the sutures are straight or slightly curved. After this, they begin to become saw-edged in form, growing slowly into the forms typical of the adult. With increasing age, the sutures grow together more and more, finally disappearing entirely; those of a woman, however, join up considerably later than those of a man. The appearance and degree of fusion give an opportunity of estimating an age up to 50 years old.

If the cranium is exposed to great heat, the sutures split up, but if they have grown together completely, the cracks resulting from the heat may take a new path. To some extent, this circumstance makes possible an estimation of age even from small portions of the roof of a cranium. The thickness of the roof of the cranium and also the character of

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the outside and inside parts of the walls and the intermediate parts give information that may be used as a guide for determination of the age of an individual.

The form of the wedge bone part of the inner ear differs in children and adults. This part is already formed at the fifth month after conception. The epiphyses at the ends of the long bones fuse with the diaphyses at fixed stages in the development of the skeleton. This occurs when the increase in length of the particular limb is complete. Therefore, it is important for the determination of age to note whether this calcification has occurred and to what extent.

Length of Body

The approximate body length of an individual may be determined from the skeleton or a part of it, assuming that some of the longer bones of the limbs (femur, fibula, tibia, humerus, radius, and ulna) are found. The length of some of these is measured, after which the body length is calculated with the aid of formulae and tables developed by anthropologists. The values given by the tables represent the length of the skeleton and should be increased by an inch or so to allow for other tissues and to give approximately correct value for body height.

Hair Color

Hair is very resistant to change providing it has not been exposed to fire, but it may often be difficult to find at the scene of a discovery when the body has changed greatly. Generally, only the hair of the head — more rarely hair from other parts of the body — can be used as a basis for estimating hair color as required for a description. Great caution should be exercised, however. Surprising changes in the color of hair may have taken place after even a comparatively short time, depending on the character of the soil and other such factors.

Blood Type

Blood types are potential means of identification of both living and deceased subjects. Information obtained from blood grouping cannot conclusively identify an individual in the same way that a fingerprint can. However, it can certainly eliminate a person and can even add to other, less conclusive types of identity information to assist in forming an opinion about identity.

Blood taken from a deceased person is subject to decomposition and deterioration. The specimen of blood used for typing should be taken from the heart or major blood vessel rather than from the body cavity. Blood samples should be preserved in EDTA (ethylenediamine tetracetic acid) preservative.

A deceased person's blood must be compared with hospital or military records. Red Cross records may also be sought. The investigator should be aware of possible errors in hospital and military blood-typing records and not base the conclusion of identity solely on these documents.

Only the ABO and Rh blood grouping systems are available in hospital and military records for use in identity determination. DNA typing (discussed in the section on forensic biology in Chapter 8) is also useful for identification purposes. If the victim received a transfusion prior to death, that information should be made known to the forensic biologist performing the blood typing.

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Identification in Mass Disasters

In occurrences of a catastrophic nature in which a large number of people are killed, such as terrorist incidents, rail and airplane accidents, big fires and explosions, the collapse of a building, and accidents at sea, the work of identification must be organized as quickly as possible and carried out in such a way that there is no danger of faulty identification of the bodies.

The federal government plays a key role in the recovery and identification of victims of mass casualty. The U.S. Department of Health and Human Services, National Disaster Medical System, is a major partner in such efforts. The U.S. Government has significantly reorganized many disaster-related areas into the Department of Homeland Security. Much of the latest information on these topics is available on the Internet.[8]

The primary responders for a major disaster come from a volunteer organization, DMORT, the Disaster Mortuary Operational Response Teams.[9] DMORT members are required to maintain appropriate certifications and licensure within their discipline. When members are activated, all states recognize licensure and certification and the team members are compensated for their duty time by the federal government as temporary federal employees. During an emergency response, DMORTs work under the guidance of local authorities by providing technical assistance and personnel to recover, identify, and process deceased victims.

It is not only for sentimental considerations that accurate identification is essential. Legal requirements for proof of death must be satisfied. Issues concerning pension rights, the payment of insurance, and estate matters depend on the correct identification of the dead. In addition, consideration of religious beliefs and psychological health of victims' families are major considerations in mass casualty situations.

If available, it is important to obtain a list showing all persons who may have been killed. In some commercial transportation accidents, this can be obtained from the passenger list. When the information is available, the task of identification is easy as long as the victims are not badly mutilated or burned or the bodies have not undergone any considerable amount of decomposition.

The work of identification should preferably be done by groups, which generally consist of teams made up of a pathologist and a dentist, and police officers and others with experience in the identification of dead bodies. The group also needs assistants varying in number for each particular case. The identification group should be present when the first measures of rescue and clearance are started at the scene of the catastrophe and, as bodies are found, they should take charge of them. If the group cannot be organized or does not reach the scene in time, a suitable police officer should be assigned to take the first steps in securing the bodies.

Before beginning, it is worthwhile to establish a command post and chain of command. In certain mass disaster situations, the federal government is in charge of the investigation and local agencies are there as support. In other instances, the reverse may be the case. It will aid the investigation and subsequent identification of victims if these details are worked out quickly and the actual work is begun.

Many public safety agencies today have prepared for mass disaster scenarios, developed procedural manuals, defined responsibilities and stockpiled supplies for such an event.

[8] See, for example, http://ndms.dhhs.gov/index.html; http://www.mmrs.hhs.gov/

[9] http://www.dmort.org/

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Those who are faced with a major event for the first time would do well to call for assistance because the task may be enormous and beyond smaller agencies' resources and readiness,

As with any possible crime scene, documentation of the site and the scene must be done. When possible, all items should be photographed. Those present at a major scene should expect a degree of chaos until adequate resources can be assembled. The health, safety and psychological well-being of personnel who staff a major disaster is an important consideration for those charged with coordination of the investigation and recovery efforts.

The record is made during the course of the work. When the body of a victim is found, it is given a number that is written on a card affixed to the body. Any objects found beside the body may be presumed to be personal belongings and are collected in a bag that is also numbered. When possible, each victim and object should be provided with a label giving more detailed information, e.g., who found it, the time of discovery, and a statement of the nature of the location, preferably in the form of a simple sketch. The objects are entered in the record in succession in a way to which others can easily refer to them and the position of the object in relation to the body is recorded. Photographing should be done thoroughly. The photographing and sketching must be considered a precaution that may possibly be of use in the work of identification. The numbered places of discovery are also marked on the sketches. If parts of bodies are found, they are given new numbers and placed in strong bags. If a pathologist present confirms that the part belongs to a particular body, then the two are placed together, but this must be done only on the authority of a pathologist. As victims are found and the proper measures are taken, the bodies are wrapped in sheets or cloths so that loose objects cannot fall out and get lost. The bodies are then taken to a suitable place where the work of identification is to be done.

When the scene of a catastrophe is so large that the bodies can neither be collected by the identification group alone nor protected by police personnel working under the group, then the victims must first be brought to the identification point by suitable means. There each body or, more likely, portion of a body is given a number and labeled with an accurate statement of the position where it was discovered, time of handing over, and name of the person who found and transported it. If possible, the stretcher bearers who collect the bodies should be given instructions as to their activities so as to avoid any mistakes.

Under all conditions, the scene of the catastrophe should be cordoned off as quickly as possible, and the guards should see that unauthorized persons do not take part in the rescue work. Stretcher-bearer patrols should be under the command of a specially selected supervisor, preferably a police officer. Relatives of deceased persons should not be allowed to take part in this work because they may choose an unidentified body that they think they can recognize, but is possibly a different individual. The presence of the relatives at or near the scene is desirable, however, because they possibly can give information that can help in the rescue or identification.

When the scene has been cleared or thoroughly searched, all bodies and remains have been found, and all objects assumed to belong to victims have been collected, the work of identification can start. The record made during the first stage should be written up in a clean copy and the photographs arranged in order as quickly as possible so that they will be available for reference together with the sketches.

During the time taken for the rescue and clearing up, and before the actual identification is started, the police authorities should obtain information on the number of persons involved and a listing of their names, occupations, and dates of birth. If it is anticipated that the identification will be difficult, then statements that can assist the identification

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Figure 6.24 (Color versions of parts C and D of this figure follow page 256.) A mass disaster created special identification problems. A commercial airliner crashed in Los Angeles. (A) An aerial photograph depicts the extent of the disaster. (B) and (C) show some of the scene at ground level and the personnel needed. (D) The remains of one of the victims await removal to a temporary morgue where various specialists will try to make an identification. *(Los Angeles County Sheriff's Department.)*

must supplement the list of names. These are obtained from the relatives of the deceased or from persons who know them sufficiently well. In an especially difficult case, the following information should be obtained:

1. Description, preferably in the form normally used by the police
2. Any illnesses, operations, or bone fractures (possibly x-ray photographs)
3. Fingerprints, if they have previously been taken for any reason
4. Photographs (simple amateur pictures are better than retouched studio portraits)
5. Dental history

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Figure 6.24 (continued)

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Figure 6.24 (continued)

6. Description of garments and shoes (if possible, samples of cloth and place of purchase, make, size, markings, repairs, etc.)
7. Description of personal belongings that might be presumed to be the deceased's clothes, together with rings, jewelry, and watch; a statement may also be needed about what would have been near the deceased, e.g., briefcase, handbag, or traveling case

Thus when the work of identification begins, all bodies, portions of bodies, and objects have been numbered in sequence. This numbering is preliminary and should be employed only as an aid to identification.

In the identification, a start is made with the least injured bodies or with those that offer the best possibilities of quick and satisfactory identification. One of the police officers in the identification group keeps the record. The bodies are renumbered in the order in which they are examined. In the work of identification, the bodies should lie on a suitable table or bench. All loose objects in or on the clothing or on the body are recorded and then placed in a bag.

If any identifying documents such as a passport, visiting card, identification card, or other similar items are found on a body, and they agree with statements obtained regarding a person supposed to have been killed, then the identification may be considered complete. However, in some cases identifying documents have been found on a body belonging to another person killed at the same time; when the bodies were thrown against one another,

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the documents were transferred from the owner to another person. If information regarding the dead person has been obtained, it must be compared with the body to confirm the identification. The first body examined is given the number one, after which numbers are given to the bodies in succession as subsequent measures of identification are taken. The bags containing the belongings are given the same numbers as the bodies to which they belong and clothes are bundled together and given corresponding numbers. Statements regarding injuries and assumed cause of death are made in the usual manner. The pathologist decides whether these statements should be made in a separate report or included in the report of the identification.

As the bodies are identified, they are put to one side. Clothes and belongings are placed next to the bodies. It is safest not to allow a body to be removed before all the others have been identified so that any mistakes can be rectified in time. When the deceased are placed in coffins, the work should be supervised and controlled by at least two members of the identification group. The coffins are marked with number and name.

The work of identification then proceeds to the more difficult cases and the identification group must rely more on and refer to statements that have been obtained. In due course, it can become easier to work on the principle of elimination. However, this method cannot be employed except in cases where information on the number of victims and their names is absolutely reliable and the statements obtained are detailed and reliable. For the most difficult cases, the group must work according to the method described in the preceding sections of this chapter. It is especially important that the dentist make a complete report on the teeth of each body.

In cases of a large number of victims, the police or other authorities should not allow the body of any victim to be removed before the identification group has been organized and arrives at the scene. Even if, at an early stage, a particular body can be identified with absolute certainty, its removal should not be permitted. The identification group has the responsibility of identifying all the victims. If this group deals only with the difficult cases, it could be under the suspicion that the bodies released earlier might have been wrongly identified, which could eliminate the possibility of certain identification of the last, more difficult cases.

Establishing identity is one of the most important uses of physical evidence. The investigator should make maximum use of experts in various fields, such as fingerprints, handwriting, dentistry, anthropology, etc., to assist in the identification of a subject.

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7 Trace Evidence and Miscellaneous Material

Trace evidence is a generic term for small, often microscopic material. Such evidence may easily be overlooked in crime scene investigations unless proper care is exercised in the search. The variety of trace evidence is endless. The purpose of this chapter is to examine some of the more common types of trace materials frequently encountered in criminal investigations and to discuss concepts of collection, preservation, identification, and use of these materials.

When an individual comes into contact with a person or location, certain small and seemingly insignificant changes occur. Small items such as fibers, hairs, and assorted microscopic debris may be left by the person or picked up from contact with the environment or another individual. In short, it is not possible to come in contact with an environment without changing it in some small way by adding to it or taking something away from it. This concept of transfer is the so-called Locard Exchange principle and is the basis for studying trace evidence.

The importance of exchange evidence is that it links suspects to victims or locations. It is physical evidence of contact and, although microscopic, can become a significant part of an investigation.

Sources of Trace Evidence

Clothing

Clothing is an excellent source of trace evidence. Microscopic and macroscopic substances may cling to clothing by static electricity or become caught in the fabric. Useful evidence is most likely to be found if the clothes are collected from the suspect or victim as soon after the crime as possible. Small items of evidence no bigger than a fiber may easily be dislodged from the clothing and lost.

After the suspect is apprehended, his or her clothes should be cursorily inspected for obvious physical evidence connected with the crime. If evidence is observed, its location and description should be noted.

If possible, the subject should be made to undress while standing on clean wrapping paper. The paper will catch any trace evidence that might fall from the clothing. The clothing should then be collected, tagged, or marked for chain of evidence purposes and

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packaged in paper bags. Plastic bags should be avoided when packaging clothing because the clothes may mildew. Care should be taken when placing the garments into paper bags; they should never be shaken because that might loosen or dislodge trace evidence. If the clothes are wet or bloodstained, they should first be allowed to air-dry prior to packaging.

It is especially important to keep the suspect's clothing away from any sources of trace evidence located at the scene. If known samples from the scene have been collected as exemplars, they should never be packaged with the clothing.

Case

Police were called to the scene of a warehouse burglary. The suspects gained entrance by chopping a hole through the roof. Officers at the scene collected samples of roofing tar, wood, and plaster to be used as exemplars for any trace evidence that might be found on the suspects. The suspects were subsequently arrested a short distance from the scene of the crime. They were taken to the police station and their clothes were examined. Some building materials and tar-like material adhering to their pants in the knee area were noted. The clothes were packaged in paper bags along with known debris specimens collected from the crime scene.

When the evidence arrived at the crime laboratory and was opened, it was discovered that the known material had been thrown into the paper bag along with the clothes. Although building material was found on the pant legs of the suspect's clothing, it was impossible to determine whether the debris came from the crime scene or the exemplars submitted in the paper bag.

Similarly, a subject should not be brought to the crime scene while clothed in the same garments worn during the crime. This will stop the argument that any trace evidence found on the clothes was from the visit to the scene while in the custody of the police.

Once clothing has been collected and packaged in paper bags, it should be submitted to the crime laboratory for careful examination. Although some police agencies may have equipment to vacuum the garments and send the sweepings to the laboratory, it is preferable to allow the laboratory to conduct the search. In instances in which extremely small items of evidence such as a single hair or fiber might be lost, evidence should be carefully packaged in a test tube, pillbox, or other appropriate container. Naturally, the location of this evidence should be noted and the items appropriately marked for identification.

Clothes from murder and assault victims pose other problems for consideration. As on a suspect's clothing, trace evidence may be present on the victim's clothes as well. These garments, however, may have been removed by other than law enforcement personnel who usually are not knowledgeable about proper collection and preservation of evidence. Problems invariably arise when paramedics or hospital personnel remove clothing during life-threatening emergencies. It is not uncommon for clothing to be cut off the victim with the aim of initiating emergency procedures. Often this results in cutting through bullet holes, tears caused by stabbing, and the like. Frequently, wet bloodstained garments are rolled up and packaged in a large plastic bag and tightly sealed.

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In these instances of improper evidence handling by emergency medical personnel, police agencies can do little more than attempt to educate those groups and hope that the potential value of the evidence was not too badly diminished. Crime laboratory personnel should be advised that the victim's clothing was cut off so that they can effectively interpret the information in their attempt to reconstruct the crime.

Clothing on deceased victims requires further considerations. Before the victim is undressed, the body should be carefully examined for trace evidence by the investigator, criminalist, and/or pathologist. The clothing should be carefully removed and placed onto clean wrapping paper. In most instances of violent death, the clothes will be wet from blood. The garments should be air-dried prior to packaging.

Footwear

Shoes and other footwear are valuable items of evidence. They may have dust, soil, debris, vegetation, or bloodstains on them. In addition to the presence of trace evidence, shoes and other footwear are useful in shoe impression evidence comparison (Figure 7.1). Shoes should be individually packaged to avoid cross contamination. Particular care must be taken when packaging footwear evidence containing clumps of dried soil. Careful examination of the soil might lead to determination of the path that a suspect took. This possibility would be greatly lessened if the soil became dislodged and pulverized in transit to the laboratory.

Evidence from the Body

Useful trace evidence may be discovered by a careful examination of the suspect and/or victim's body. Injuries caused by a struggle between victim and suspect may be noted. Microscopic particles of gunshot residue are often present on the hands of a shooter following discharge of a firearm.

Hair is sometimes found on the victim's body in rape cases. Bloodstains on a victim or suspect's body are not uncommon in assault and murder cases. A close examination of the head, ears, fingernail scrapings, and hands may yield traces of debris from a burglary, assault, or other crime in which there was contact between the subject and another person or the crime scene.

Trace Metal Detection

The trace metal detection test, or TMDT, has been used with mixed results. The solution is sprayed on the subject's hands and observed under ultraviolet light. The presence of dark areas indicates the location of metal. Different metals give somewhat different colors.

The TMDT is commonly used to test whether a subject recently held a metal object, such as a weapon. In the case of a handgun, it is sometimes possible to see the location of the trigger on the index finger and the location of the strap, the metal frame that touches the palm (Figure 7.2).

The problem with the test is that results are not always consistent or predictable. We live in a highly technological society and come into contact with metal objects every day, so some amount of background trace metal will always be present on a suspect's hands. In addition, experiments with the method have shown that holding a handgun with a metal frame and test firing it does not always produce a positive trace metal detection test.

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Figure 7.1 (A) Shoes seized from a breaking-and-entering suspect. Arrow indicates piece of glass in the crepe-rubber sole. (B) A close-up of the sole of the left shoe showing the piece of glass from the crime scene embedded in the tear. *(Royal Canadian Mounted Police, Forensic Laboratory Services.)*

Apparently, the amount of perspiration on an individual's hands will significantly change the results of the test. Also, if a suspect is in an environment in which there is metal, grasping an object will result in a positive test. Washing or any kind of mechanical motion of the hands naturally lowers the likelihood of a positive result.

If the investigator's purpose in using the TMDT is to determine whether a suspect recently fired a weapon, other test procedures are available. Gunshot residue (GSR analysis) may be considered.

Other Objects as Sources of Trace Evidence

Trace evidence may be present on tools and weapons, as well as other objects. When possible, the items should be carefully wrapped to protect the material on them. This may be done best by placing a paper bag secured by cellophane tape over smaller objects. If the instrument bears larger particles that may be lost, the particles should be carefully removed and placed in appropriately labeled containers.

Tools used in burglaries may contain traces of building material, metal shavings, paint, and so forth. These items may be used to establish a connection between the tool and the location. Similarly, a weapon such as a knife may have hairs or fibers present that may prove to be useful evidence (Figure 7.4).

Larger items may be fruitful sources of trace evidence, for example, a vehicle from a hit-and-run accident. Naturally, objects of this size cannot be routinely brought to the

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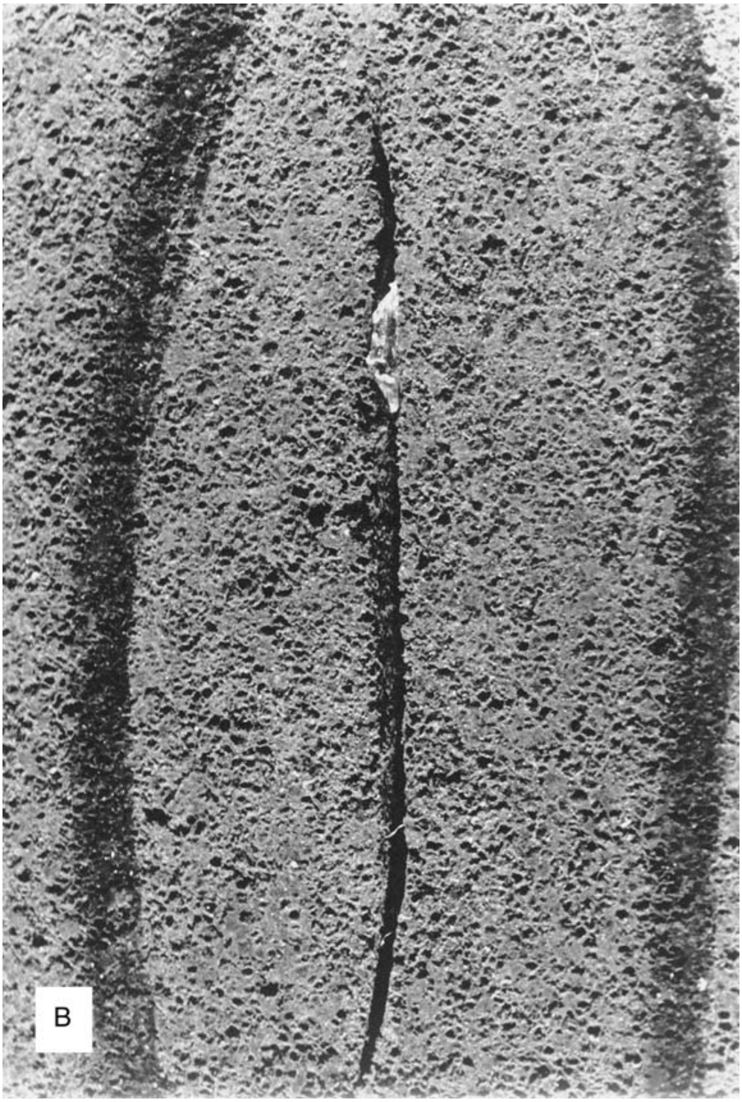

Figure 7.1 (continued)

laboratory. However, a careful examination in the field can turn up hairs, fibers, skin, blood, and the like.

Microscopic evidence presents more of a challenge than a problem to modern crime laboratories. Use of low-power and high-power light microscopes and sophisticated instruments, such as scanning electron microscopes and various types of spectrographic tools, makes the examination and characterization of minute items of evidence commonplace.

A far greater problem than size is quantity of material. Particles and material collected from vacuum sweepings and careful searches of evidence can yield thousands of microscopic items to be examined. Only patience and the examiner's expertise can ultimately determine the nature and utility of the collected items.

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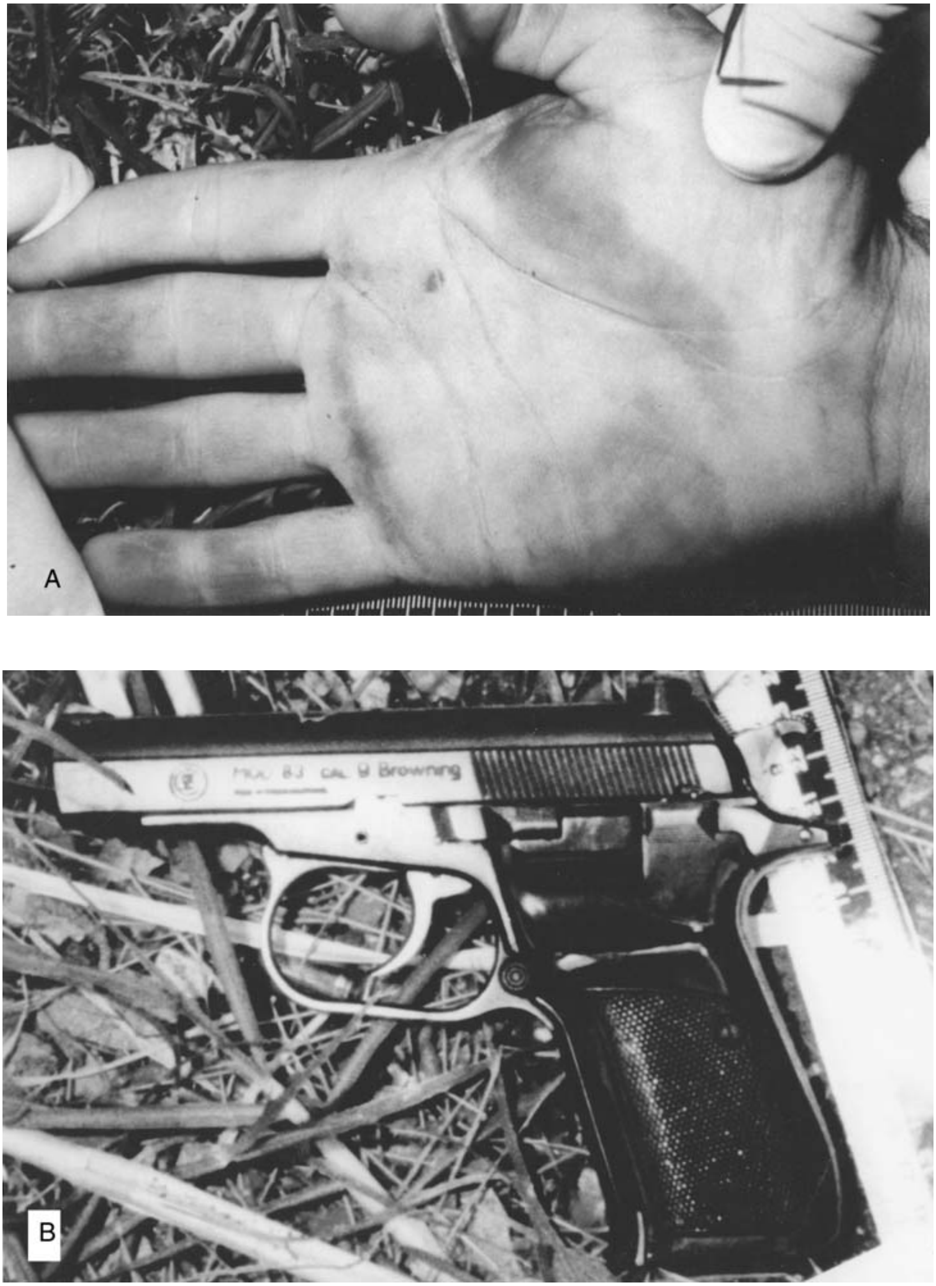

Figure 7.2 (A color version of this figure follows page 256.) The appearance of a violet-magenta stain on the hand is the result of a chemical reaction between the reagent and iron found on the gun. This case was a suspected suicide in which the victim held the gun in the opposite direction. The stain (A) extending from between the thumb and index finger suggests the normal handling of the gun. The dot in the palm between the index and middle fingers indicates the gun was held in the opposite direction. The left side of the gun (B) shows the round screw on the grip that is not present on the reverse side. The appearance of this impression on the palm indicates that the gun was held backwards by the victim. Field test kits for this technique are sold under the commercial names Ferrotrace (manufactured by Ezra Technology, LTD, POB 35008 Jerusalem, Israel) and Ferroprint (manufactured by Shulamit, POB 170, Hod Hasharon, Israel). *(Division of Identification and Forensic Science, Israel National Police, Jerusalem, Israel.)*

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Figure 7.3 (A) A screwdriver seized from a suspect in a burglary case. (B) Close-up of the blade of the screwdriver. *(Royal Canadian Mounted Police, Forensic Laboratory Services.)*

Collection and Preservation of Trace Evidence

As with all evidence, the investigator or crime scene technician must be concerned with various legal and scientific aspects of collection and preservation of trace materials. Legally, issues of chain of custody and the necessity of a search warrant or court order must always be considered. Generally, case law has dictated what is necessary to fulfill the requirements of a chain of custody, as well as the need for warrants. When in doubt, the investigator should contact the local district attorney's or state attorney general's office for guidance.

Scientific requirements depend upon the nature of the evidence collected and the proximity of the laboratory conducting the examinations. It is obvious that if evidence needs to be mailed or sent by a parcel carrier, extraordinary care must be taken to preserve fragile substances properly.

A question sometimes asked is, "Is it better to remove an item of trace material from a larger item or leave it alone?" The answer is, "It depends!" If a hair, fiber, loose paint chip, or other very small and easily lost item of evidence can reasonably be expected to become dislodged or lost from the item to which it is attached, that smaller item should be removed. On the other hand, if in the investigator's opinion the smaller substance will not be lost, then it should not be handled. It is preferable to submit the entire item with

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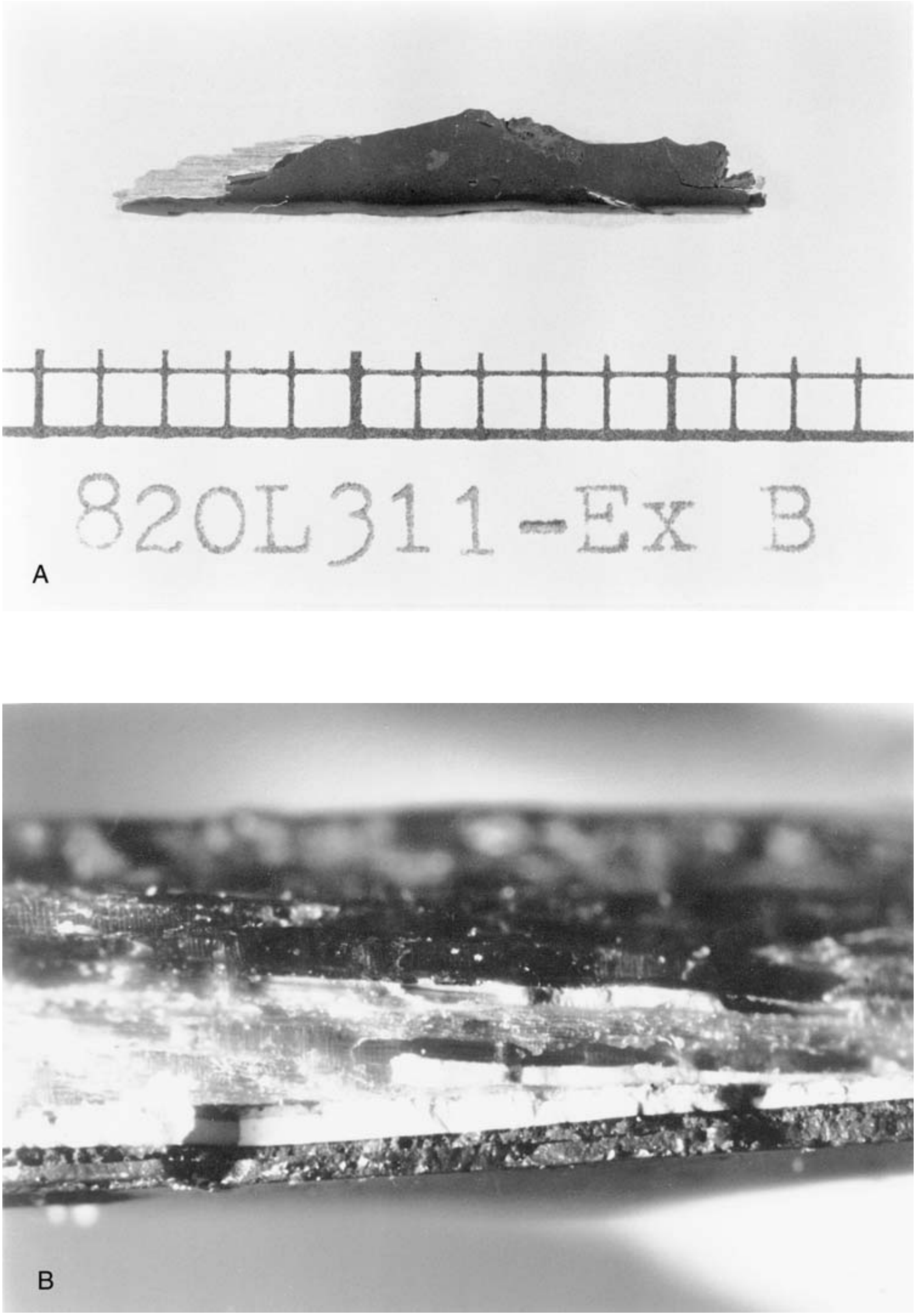

Figure 7.4 (A) Fragments of the window frame; (B) close-up of the window frame fragment. Chemical analysis of the paint pigments and binders indicated that the paint on the tool was similar and enhanced the value of this associative evidence. *(Royal Canadian Mounted Police, Forensic Laboratory Services.)*

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trace evidence attached to it to the laboratory for an examination. Of course in those instances in which the item is too large or inconvenient to transport, the trace material should be carefully removed, packaged, and sent to the laboratory for examination.

Small items of evidence should always be double packaged. Double packaging means that the evidence should be first placed into an appropriate container and secured. The first container should then be inserted into a larger container. Both containers should be appropriately marked to indicate the person performing the packaging, the date and time, the case number, and a very brief description of the item. If the inner container should inadvertently open, the outer one will contain the evidence.

As an example of double packaging, consider a hypothetical case. Suppose an investigator has observed a small fiber on the bumper of a car suspected in a hit-and-run accident. Bringing the car to the laboratory or a location where the vehicle could be raised for a thorough examination of the undercarriage would be the best way to conduct an examination. Assume this is not possible. The detective still wants to collect the fiber for comparison with the victim's clothing. The fiber should be carefully removed and placed in a test tube, small envelope, pillbox, paper bundle, or any other appropriate package. The inner package would be marked with the initials, date, time, case number, and so on and would then be placed into a second, or outer package. This outer package would also be appropriately marked.

Control or known samples are required in all cases. The investigator should make every attempt to collect a sufficient quantity of known material to be submitted with the items in question. The known exemplars must **never** be packaged with the questioned samples. This separation is necessary to avoid cross contamination of unknown by known specimens.

Almost all types of trace evidence can be placed in a class or group, i.e., identified. Only in rare cases is trace evidence of the type discussed in this chapter capable of conclusively indicating a specific source or origin. A single fiber cannot be shown to have come from a unique garment, nor a clump of dirt from a specific location. Does this mean that trace evidence is of no value? On the contrary, because of its usefulness as circumstantial evidence, trace evidence may often be the sole means of corroborating testimonial evidence in a case.

Examples of Trace Evidence

Building Materials

Building materials of a wide variety may be encountered in burglary cases. Materials such as stucco, cement, brick, mortar, plaster, plasterboard, wood, and paint constitute evidence generally considered as building materials. This type of evidence is most likely found on the clothing of burglary suspects, in their cuffs, pockets, and shoes. Another likely location for this type of debris is on tools used to break into a location.

Items suspected of containing building material debris should be carefully packaged and submitted along with appropriate exemplars to the crime laboratory.

The investigator should carefully examine the crime scene to ascertain the nature of the trace evidence. In breaking and entering cases, the point of entry or any other location indicating damage should be examined and exemplars of building material collected. If tool marks are present at the point of entry, samples of building materials should not be

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collected from the area of the tool mark, but rather adjacent to the mark. Furthermore, if an area is to be cut out, particular care must be taken not to cut through the tool mark.

In cases of building material that shows indications of tampering at several locations, it is necessary to collect known specimens of the material in question from each of the damaged areas. This is important because the composition of the building material may vary from site to site. It is very important to package each item of evidence separately, properly marking the package, and noting the location where the specimen was collected.

Tools may be useful sources of building material evidence. Bits of paint, plaster, wood, and even glass may become attached to the tool. In addition to the debris they may contain, tools are useful for tool mark comparisons and for physically matching broken pieces of the tool.

If building material is noticed at the end of a tool, the area should be carefully wrapped so as not to dislodge the evidence. If the item is too large to be transported, the trace material can be carefully removed with a clean pocketknife or razor blade onto a clean sheet of paper. The paper is then folded and placed in an envelope. Both paper and envelope should be properly marked.

The interior or the trunk of a suspect's vehicle should be searched for the presence of building materials. Vacuum sweepings may be taken for a later search of debris. Clothing is an especially good place to find building materials. The clothes should be collected from the suspect as promptly as possible to minimize any loss of evidence.

Physical, chemical, and microscopic means can characterize building materials. In most cases, building material evidence can only demonstrate class characteristics and cannot be shown to be unique to a specific source. As with other evidence of this type, it is valuable as circumstantial evidence.

Asbestos

Although asbestos is no longer permitted for use as insulation, it may be present in older buildings and some safes. It can be identified microscopically.

Safe Insulation

Various types of materials are used in fire-resistant safes to prevent the contents from burning. Some common materials used in these safes are diatomaceous earth, vermiculite, and cement, to name a few. These materials may readily become deposited on a safe burglar in the course of opening the safe. Examination of a suspect's clothing, shoes, and tools may yield safe insulation, which can be identified microscopically and chemically. Expertise in recognizing the types of insulation used by various manufacturers may allow the analyst to make an educated guess, useful for an investigative lead.

Paint

Paint evidence is frequently recovered in hit-and-run accidents, burglaries, and forced-entry cases. In some cases, it is possible to show conclusively that the paint came from a specific location if the chips are large enough and the edges can be fitted together in jigsaw

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Figure 7.5 A parked car had apparently been struck by a hit-and-run vehicle. The police, however, suspected that the complainant had struck a steel pole. Paint chips from the vehicle and base of the pole were examined. Not only did the paint from the pole match the transfer to the car, but also a physical match was made of the chip (left) from the pole and the chip (right) from the car. *(Center of Forensic Sciences, Toronto.)*

puzzle fashion. In most instances, however, only class characteristics can be demonstrated (Figure 7.5).

Paint and other protective coatings such as lacquer, enamel, and varnish can be identified by physical and chemical properties. Physical characteristics such as color, layering, weathering, and texture are useful in characterizing this evidence. Chemical properties such as solubility and composition can indicate the type of paint and identify the pigmentation and fillers used in the manufacturing process.

In some cases involving automobile paints, it is possible to determine the type of vehicle. The U.S. National Institute of Standards and Technology used to provide automobile paint standard reference samples; the standards were available only for late-model, American manufactured automobiles.

Even if a vehicle cannot be identified as to manufacturer, known and questioned specimens can be compared by examining chemical and physical properties. The best that can be stated is that the paint from the control and questioned sources are consistent, that is, they could have come from the vehicle in question or any similarly painted vehicle.

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In some instances, vehicles and residences that have been painted and repainted many times may have so many layers of paint that upon examination, the probability is very high that the two specimens share a common source. This, however, will depend on the specific case as well as the expertise of the analyst.

When standard specimens of paint from automobiles, or a door or window in a forced-entry case, are collected, the specimen should be taken as close to the area of damage as possible to lessen the possibility that an area further away from the location of interest was painted differently. In burglary cases, it is particularly important not to collect a standard or control paint sample from the pry area. The specific area of the jimmy or pry will contain a tool mark that may be compared with a pry bar or other tool found at a later time. (See Chapter 9 for a discussion of tool marks.)

When collecting paint samples in a hit-and-run investigation involving two vehicles, a total of four paint samples should be collected and separately packaged. From vehicle A, collect a sample from the point of impact that contains a paint transfer from vehicle B. Also, collect a standard paint sample that shows no damage but is adjacent to the damaged area. Similarly, two samples should be collected from vehicle B, one from the damaged area and a second from the undamaged area to be used as a standard.

If dislodged paint chips are present in the damaged area of the vehicle, they should be carefully collected and packaged to avoid breaking. They may be able to be fitted with other, larger paint chips collected from the scene of the accident or the second vehicle.

To collect a known paint sample from a vehicle, hold a folded piece of paper and tap the side of the vehicle with a pocketknife or similar device. This will dislodge some paint and allow it to fall into the paper. Care should be taken not to separate the outer layer of paint from the undercoating. Avoid using cellophane tape to collect the paint samples. It is best to place the paint sample into folded paper or a small box with a good seal. Small envelopes are not advised for this type of evidence because the seams of the envelope located in the bottom corners are generally not sealed. Paint chips placed in envelopes usually fall out through the small, unsealed space. Small plastic bags should also be avoided because they have a static electric charge that makes it extremely difficult to remove the chips once the evidence is received at the laboratory.

Paint on tools should not be removed. It is preferable to wrap the end of the tool carefully so as not to dislodge the paint and submit the tool to the laboratory with the paint intact.

Rust

Rust stains may sometimes be confused with bloodstains. However, rust can easily be differentiated from blood by a simple chemical field test.

Metals

Filings, shavings, and other metal particles can easily be identified chemically or spectrographically. It is possible to make a comparative analysis of a known and questioned metal sample that can show class characteristics (Figure 7.6). Metal filings located in the jaws of pipe wrenches are fairly common sources of this type of evidence. The wrench is used as a burglary tool by placing it onto a doorknob. Metal filings present in the teeth can be compared to those from the doorknob.

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Figure 7.6 In the case of an alleged jailbreak attempt, the investigator wanted to know whether the inmate had used a hacksaw blade on his leg chains. When the crime was reenacted, a magnet was able to pick up numerous metal particles from the clothing of the investigator, whose hand was also slightly injured from using the blade. None of this evidence was found on the inmate, calling into question the hypothesis that he had tried to escape on his own. *(Los Angeles County Sheriff's Department.)*

Case

A 13-year-old boy, evidently quite bright, decided to poison his mother slowly with mercury. He collected enough mercury by breaking into a number of homes in the neighborhood with a 17-year-old friend and removing the mercury in their thermostat switches. He may have read that mercury salts are highly toxic and mistook this to mean that elemental mercury and table salt together are highly toxic. Whatever the reason, he placed the mercury in a glass salt shaker along with table salt, shook the contents to break the mercury into fine droplets, and left the shaker to be used by his mother.

The forensic science laboratory was requested to show that the shaker had been used to dispense the mercury. The lid of the shaker was examined using a scanning electron microscope (SEM) with an energy dispersive x-ray detector (EDX). This combination allowed the operator to magnify an image of the object and determine its elemental composition. The lid of the salt shaker was made of plastic coated with nickel and chromium to give it a shiny appearance. The area around the holes in the shaker's lid was examined for traces of mercury and, using the SEM, one fine droplet of elemental mercury, clinging to the nickel plating at one of the holes, was found and identified as mercury with the EDX (Figure 7.7).

Textiles and Fibers

Fragments of cloth may become evidence in a wide variety of cases. Torn fabrics have been examined in murder cases in which the victim was tied and gagged with torn fabric, in burglary cases in which a suspect left a small torn piece of clothing caught at the point of entry, and in hit-and-run cases in which torn clothing was left on the undercarriage of the suspect's vehicle.

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Figure 7.7 A glass salt shaker used by a boy in an attempt to poison his mother (A). One of the holes of the shaker was photographed using scanning electron microscopy (B). The magnification clearly shows the droplet of mercury (C). *(Center of Forensic Sciences, Toronto.)*

Fragments of textile evidence may yield class as well as individual characteristics. A portion of fabric may be physically fitted into another piece of fabric, thereby proving a common source (Figure 7.8). A number of physical, chemical, and microscopic characteristics of textiles can be used for comparison purposes. Properties such as color, type of cloth, dye, direction of fiber twist, and thread count are useful in characterizing the evidence.

When a fragment of fabric is found during the course of a crime scene search, its location should be noted, indicated in a crime scene diagram, and photographed. As with other items of trace evidence, it is preferable not to remove the fabric from the object to which it is attached. If this is not possible, the fabric should be packaged in a clean container, properly labeled with the appropriate chain of custody information.

The location of the evidence at a point of entry or the physical appearance of the fabric may be useful as investigative leads. The detective may be able to theorize the location of a tear on an article of clothing or the type of cloth evidence that needs to be found for comparative purposes.

Investigators may overlook fiber evidence because of its extremely small size compared to fabric evidence. Five types of textile fibers can be encountered as evidence: animal fibers, such as wool; vegetable fibers, such as cotton; synthetic fibers, such as polyester, nylon, rayon, etc.; mineral fibers, such as glass wool; and blends of synthetic and natural fibers, the most common of which are polyester and cotton. Fiber evidence may be transferred

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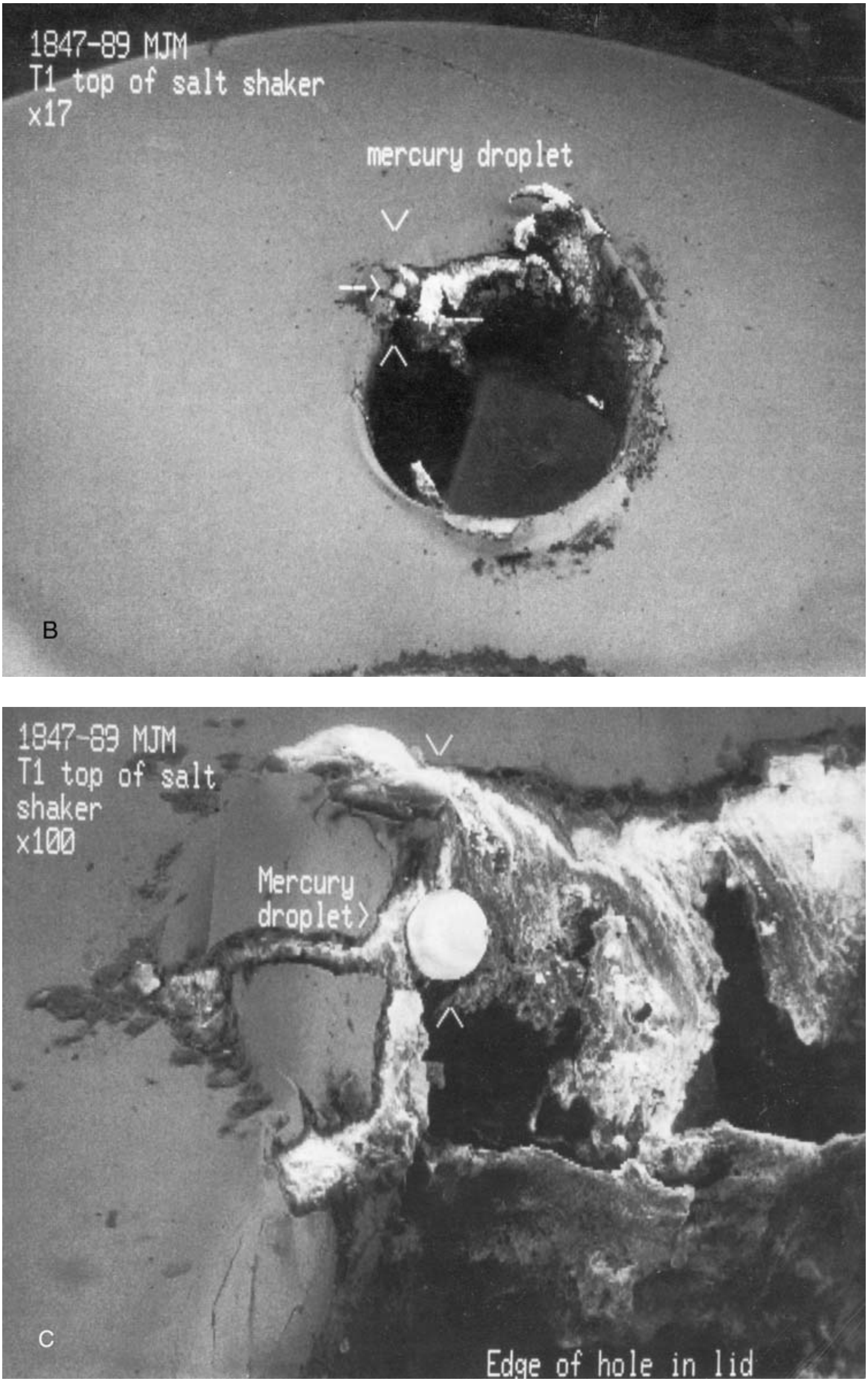

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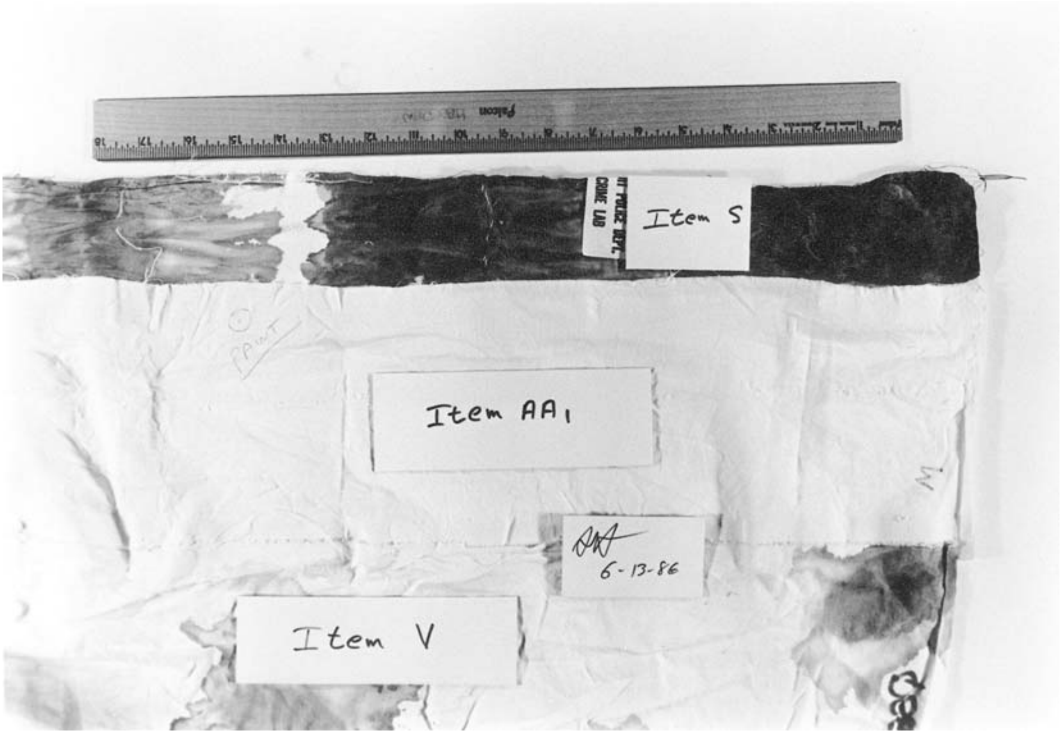

Figure 7.8 The bodies of two teenage girls were discovered with multiple gunshot wounds. One of them had been bound and gagged and covered with bedding. The bedding was a sheet with several strips of cloth missing. A search of the suspect's house was conducted, and several strips of cloth were found that matched the sheet from the scene. *(Detroit Police Department, Crime Laboratory Section, Detroit, Michigan.)*

by one person's clothing coming into contact with another's or from articles such as blankets, carpet, upholstery, and so forth. Fibers may be located on clothing, in fingernail scrapings, on hit-and-run vehicles, at point of entry, and on hair covered by knit hats.

Removal of fibers from other objects is best done at the crime laboratory. If this is not possible, fiber evidence can be removed by using forceps or cellophane tape, or by vacuum sweeping. Of the three procedures, the tape method is probably the best. A length of tape about 4 inches long is taped end-to-end, forming a cylinder with the sticky side of the tape on the outside. The hand is inserted into the center of the tape and the sticky side of the tape is pressed on the item of interest. After sampling, the tape is placed sticky side down on a microscope slide for submission to the laboratory. The procedure has its advantage in that it only collects surface material, whereas vacuum sweeping collects huge quantities of debris and forceps may miss many items of trace evidence.

The laboratory can determine the type of fiber and whether or not it is similar to the control fiber specimen. It is not possible, with fiber evidence, to state with complete certainty that it came from one and only one source because most garments and textiles used today are mass produced. It is usually not possible to determine if a specific sample came from the garment in question or from another garment of similar manufacture (Figure 7.10 and Figure 7.11).

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Figure 7.9 In a 4-month period between October, 1977, and February, 1978, the nude bodies of 10 girls and young women between the ages of 12 and 21 were found dumped on hillsides in Los Angeles County. All had been raped, tortured, and strangled. One of the victims found lying at the side of a road had a small tuft of fiber on her left wrist. *(Los Angeles County Sheriff's Department.)*

Buttons

Buttons come in a very wide range of sizes and patterns; only in exceptional cases is it possible to match a button with the buttons of a particular garment. When a button is torn off, generally the thread and sometimes a piece of fabric may be present. If exemplars of the sewing thread and the garment are available for comparison, a more definitive conclusion about the source of the button may be made. If a piece of broken button is discovered, it is possible to match the broken piece physically with another portion of the button. This type of evidence can lead to a conclusive statement about the source of the evidence (Figure 7.12).

Cordage and Rope

Pieces of string or rope are sometimes found at crime scenes. If they were used to tie up a victim, the knots should not be untied; rather, the rope should be cut and tied back together with string. The knots present in the rope may prove to be useful evidence.

Rope and cordage evidence can be compared with exemplars for similarities. Properties that can be examined include the material from which the cordage is manufactured, the number of strands, direction of the twist in the rope, color, diameter, weight per unit of length, etc. All of these properties taken together will allow the examiner to determine whether the material is of a similar manufacture. Only in very rare cases in which a

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Figure 7.10 (A) Fibers were subsequently collected from a chair (B) found in the suspect's home almost two years after the murders and compared. The suspects, Angelo Buono, a 48-year-old auto upholsterer, and his cousin, a 32-year-old former security guard named Kenneth Bianchi, posed as police officers and "arrested" young women, who were then raped and sodomized, and sometimes tortured before being slowly strangled to death. *(Los Angeles County Sheriff's Department.)*

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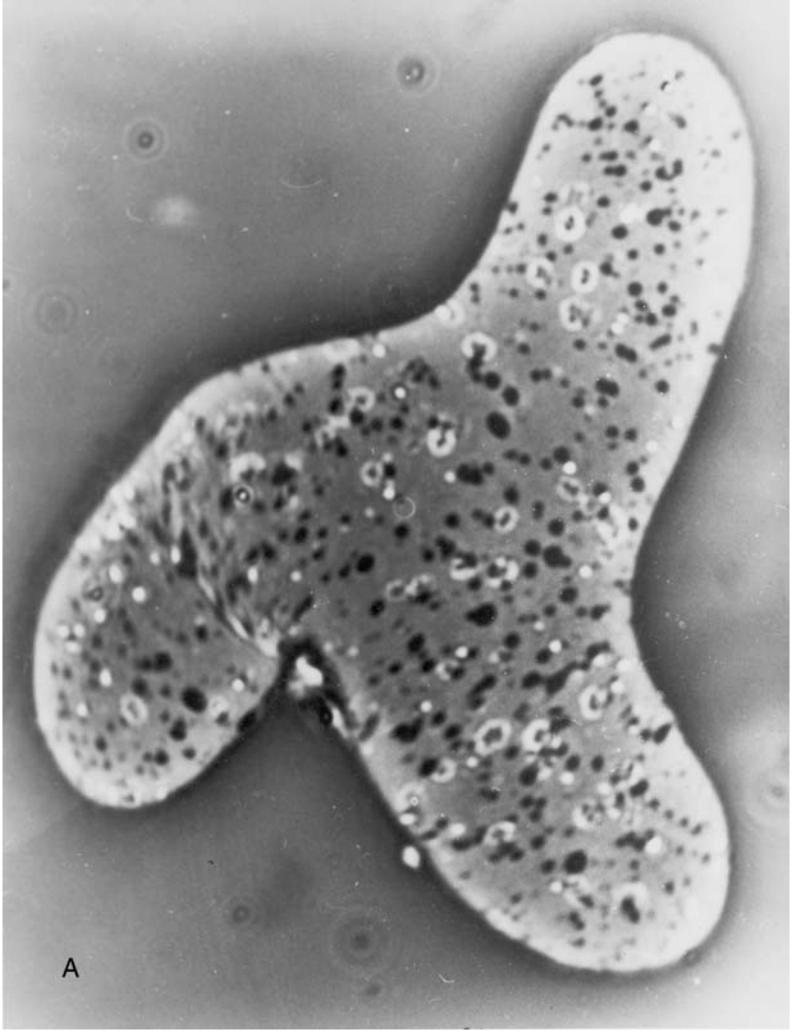

Figure 7.11 Fibers from one of the cases linked the victim to the assailants' home. A Monsanto Cadon® fiber (A) made only between 1968 and 1974 and a second rare modified "Y" fiber (B) produced by Rohm and Haas for a short period of time were important evidence in the trial. The defendants were found guilty of nine counts of murder and sentenced to life imprisonment without the possibility of parole. *(Los Angeles County Sheriff's Department.)*

microscopic examination indicates that a cut rope came from a specific exemplar can a conclusive statement of source be made (Figure 7.13).

In some cases, rope and cordage evidence may have other trace evidence attached to it. In cases of strangulation it may be possible to identify epithelial (skin) cells attached to the cordage.

Cigarettes and Tobacco

Cigarettes, cigarette butts, tobacco, and ash are frequently found at crime scenes and just as frequently overlooked as potentially useful evidence. From the point of view of forensic science, very little work has been done in the identification of tobaccos. This does not lessen, however, the possible use of this type of evidence.

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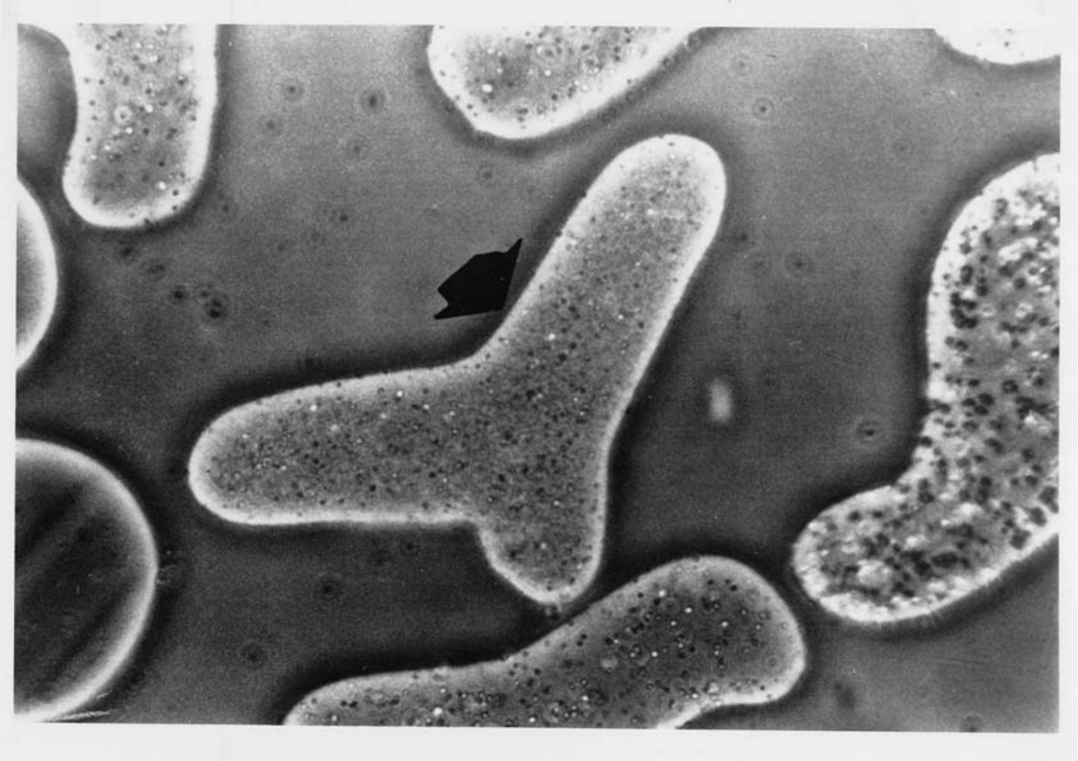

(B)

Figure 7.11 (continued)

Figure 7.12 (A) A button found at a burglary scene compared with one found on the suspect's jacket (B). A photomicrograph (C) shows manufacturing marks indicating common class characteristics. *(Orange County Sheriff-Coroner, Santa Ana, California.)*

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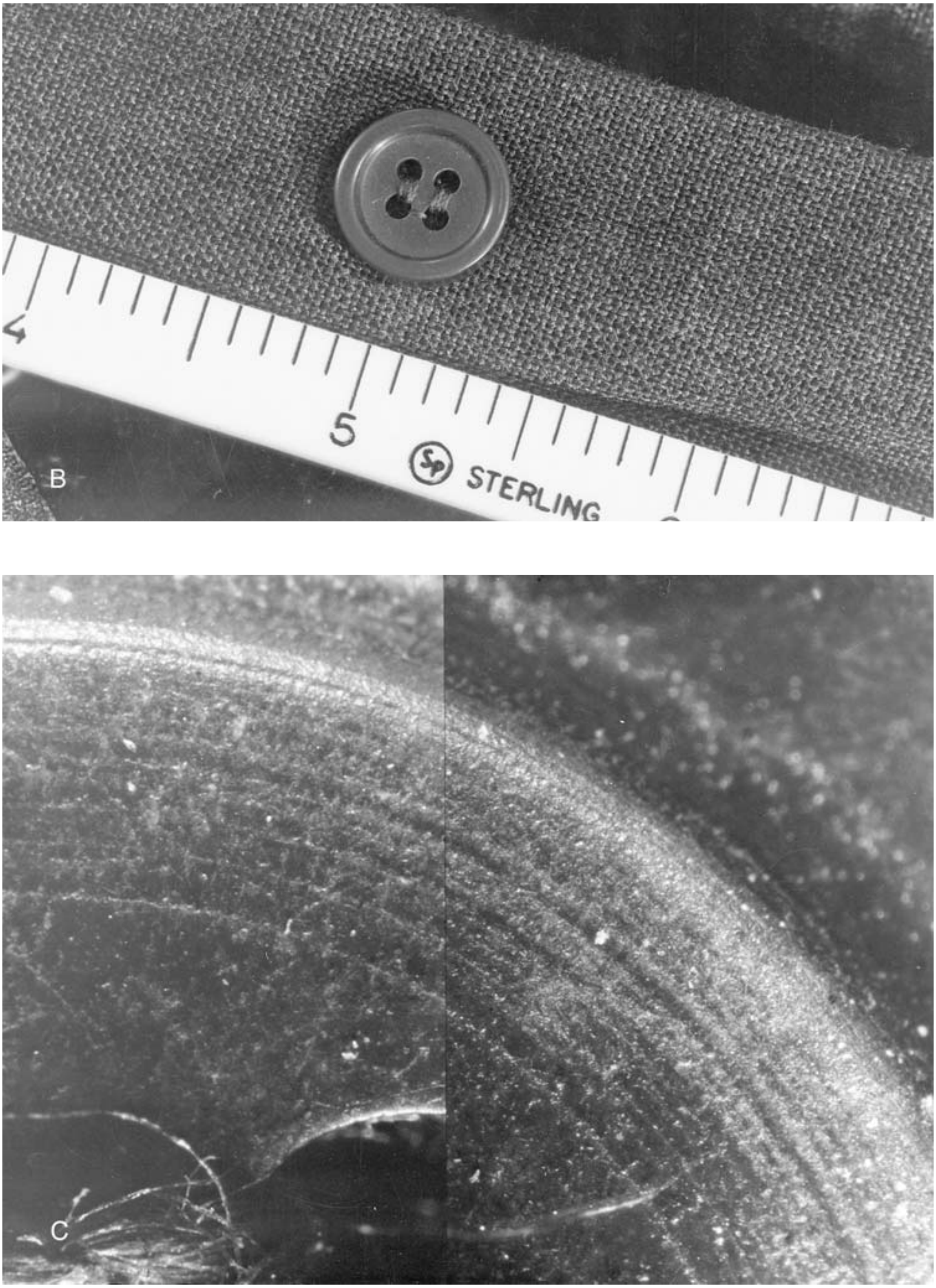

Figure 7.12 (continued)

Several laboratories maintain cigarette libraries from which they can often identify the brand from a cigarette butt. In some cases, information about the brand a subject smokes may be useful to the investigation (Figure 7.14). Similarly, the appearance of ash left at a location may indicate that a suspect smoked a pipe or cigar, which is useful in describing the habits of that individual.

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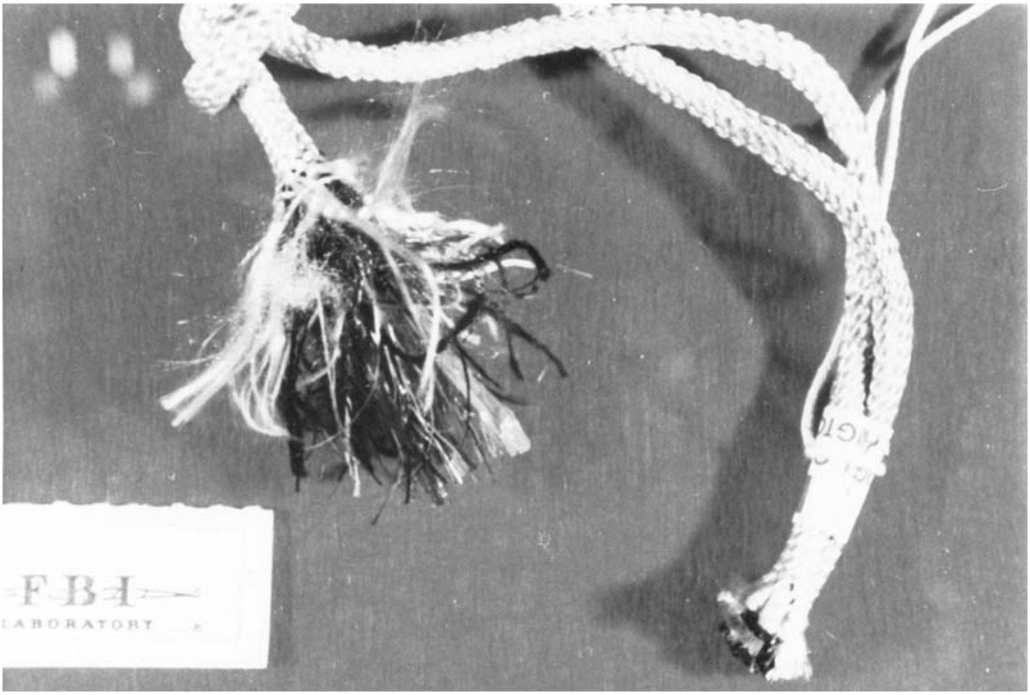

Figure 7.13 The body of a young male victim was discovered bound with a white, nylon-braided rope with a highly unusual core consisting of 24 different types and/or colors of yarn and a total yarn count of 106. The yarns consisted of polyesters, rayons, polypropylenes, sarans, cotton, acetates, nylons, and monoacrylics. Rope similar to this very unusual type was found in the possession of a suspect who later confessed to the murder when presented with the evidence of the case. *(Federal Bureau of Investigation.)*

Figure 7.14 (A color version of this figure follows page 256.) Sometimes seemingly insignificant items left at the scene are important. The cellophane wrapping from a pack of Marlboro cigarettes was shown to have come from a pack of cigarettes found on a suspect. *(Los Angeles County Sheriff's Department.)*

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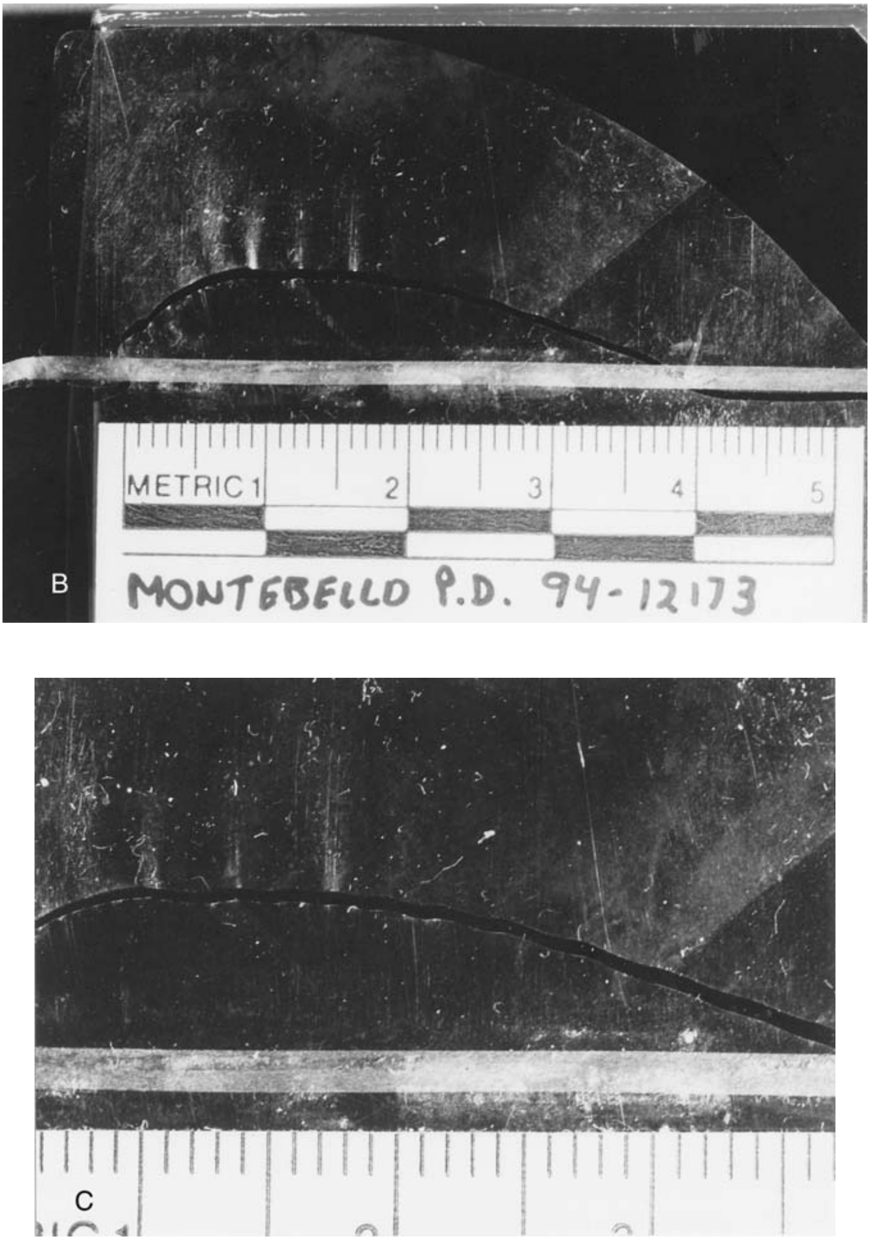

Figure 7.14 (continued)

Cigarette butts may be a useful source of other physical evidence. In some cases, latent fingerprints have been developed from cigarette butts by the ninhydrin process. It is also possible to determine the smoker's DNA from the saliva left on the butt. Although latent prints and DNA typing results may be negative, these procedures should be considered.

Empty cigarette packages are frequently found along with cigarettes. Besides the brand and the possibility of determining fingerprints, it is sometimes possible to determine the general location of the sale of the cigarettes by the numbers on the package. The ability to determine the area of sale depends on whether or not the distributor kept records of these numbers.

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Matches

Matches found at a crime scene may be from smokers or from suspects who used them to light their way. Several may commonly be found in burglary cases. The surface of a single match is usually too small to find sufficient detail to identify a latent fingerprint. However, other useful bits of information may be determined from matches.

Matches may be wood or paper. The type of wood, microscopic appearance of the cardboard, color, dimension, and shape are useful in comparing a burned match with some exemplars associated with the suspect. Paper or cardboard matches are by far the most common kind at crime scenes and offer the best chance of directly incriminating a suspect. To show a connection, it is necessary to find the book of unused matches on the suspect, or at least at the location with this person's latent prints present. Cardboard matches are made from wastepaper. As such, there is wide variability from book to book. It is possible to show a connection between the cardboard left in the matchbook and that of the match. In some instances, it is possible to fit the match into the book by the appearance of the torn end of the match and the remaining end in the book.

Matches are sometimes used as toothpicks. If the end of the match appears to be chewed, it may be possible to determine the DNA of the chewer from the saliva.

Burned Paper

Burned papers and charred documents are sometimes found in arson investigations or in instances in which an attempt was made to destroy records by fire. Burned documents can be deciphered, provided they are reasonably intact. If the paper has been reduced to ashes it is not possible to determine any writing. For this reason, it is particularly important to exercise extreme care when collecting, preserving, and transporting this type of evidence.

If burned paper is found in a metal file box, it should not be removed from the box; rather, it should be transported in the container in which it was found. If the documents are found in the open, or if the files they are in cannot be taken to the laboratory, the paper should be carefully placed into rigid cardboard boxes. Charred papers can be picked up by gently sliding a flat piece of cardboard under them. Once picked up from the scene, they can gently be placed in boxes.

It is preferable to hand carry boxes to the laboratory because of the fragile nature of this evidence. If this is not possible, the paper must be packaged so that it will not break up in transit. Cotton or any other similar material that will preserve the evidence can be layered in the cardboard boxes.

If the paper is still burning when the investigator arrives at the scene, no attempt should be made to put out the fire, unless the air supply can be shut off without handling the document. Otherwise, the paper should be allowed to burn completely.

If the burned material consists of a book, folded papers, or currency, no attempt should be made to separate the layers of paper. The debris should be kept together and submitted to the laboratory in that state.

Chemical treatment, photography, and examination under ultraviolet and infrared light often make the writing legible in charred documents. However, the documents must arrive intact in order for such examinations to be conducted.

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Ash

The composition of ash will vary greatly depending upon the source. It can sometimes be identified microscopically, chemically, or by means of spectroscopy. However, the source of the ash may prove difficult to determine. One type of ash common in arson cases is the residue of burned highway flares. This ash contains a significant level of strontium, responsible for the bright red color of the flare.

Soil

Soil evidence may be encountered in a wide variety of criminal investigations. It may be found on shoes, clothing, or the underside of motor vehicles and is useful in tying the suspect or victim to a location. A tire or footwear impression in soil makes it possible to prove that the subject was in fact present. (See Chapter 9 for a discussion of impression evidence.)

Soil is a mixture of decaying and weathered rock and decomposed organic material known as humus. It contains a wide variety of minerals such as quartz, feldspar, and mica as well as partially decomposed leaves, pine needles, pollen grains, and other plant fragments. Thus, it is easy to differentiate soils from various locations by microscopic examination of various components.

Known soil specimens from the crime scene are absolutely required for an analysis of the evidence sample. Samples should be collected from various regions at the specific location in question and several feet away from it, and at other locations, such as the subject's home and work, for elimination purposes.

Known samples can be placed in individual small glass jars or metal cans. Clean baby food jars are useful for this purpose. Two or three tablespoons of topsoil are all that is usually required for known specimens. It is important not to dig deeper than an inch or so when collecting these specimens. The subsoil may have a significantly different composition from the topsoil and lead to confusing results. Again, the containers should be appropriately labeled and the location of each sample noted.

Soil specimens on shoes and other objects should be carefully handled. In certain instances, in the lab it may be possible to remove successive layers a little at a time and reconstruct the activities of the subject based upon the different types of soil present.

Case

A murder victim's home was entered through a bedroom window. Beneath the window was a somewhat muddy planting area. A poorly defined footprint, believed to be the suspect's, was found in the planting area. A suspect was arrested a short time later and the police confiscated his muddy shoes. The suspect maintained that the mud was due to some gardening work he was doing at his home.

Soil specimens were submitted to the laboratory from several locations at the crime scene, the suspect's home, and two other locations where the suspect claimed to have been that day. The examination of the evidence indicated that the soil on one shoe did not come from the suspect's home or either of the two other locations. The soil was consistent with that from the crime scene. The other shoe contained

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two different soils, one consistent with the suspect's home and the second consistent with the crime scene.

Wood

As evidence, wood may be present as sawdust, splinters, chips, large pieces used as assault weapons, etc. Evidence may be present at the crime scene, on a suspect's clothing, or in a wound. Wood may also have tool marks.

Because of the wide variety of wood types and its use in building, furniture, and hand tools, this type of evidence is most valuable. It is possible to identify, compare, and match sources of wood evidence.

Wood may be divided into two types: hard woods and soft woods. It is possible to determine the type of wood and often the type of tree from pieces the size of sawdust particles. The examination of wood is done microscopically.

If the question is to decide whether two pieces of stem from a tree originally belonged together, the original external contour of the stem is a good guide, if it is in good condition. Cracks in the bark, structures and formations on the surface of the bark, and the position of the sawed surface in relation to the longitudinal axis of the trunk, together with the placing and general appearance of any felling cut, have their own significance for the task of identification, which is simply a matter of seeing how the different pieces fit together. By matching them against one another it is frequently possible to determine the correspondence between two pieces of wood separated from each other in the longitudinal direction of the tree.

The annual rings of a tree are very characteristic. By making a transverse section of an object under investigation it is often possible to obtain a picture just as characteristic of the tree, within a limited region of the stem. Bruises and decay in the wood are often characteristic in position and extent, and may assist in identification.

If an object under investigation is made from wood that has been worked in some way with tools (knife, plane, saw) or has been painted or surface treated in any other way, the possibility of identification is increased. Imperfections in the edge of the knife or plane blade (including planing machines) leave characteristic marks that can possibly be found on both pieces of wood. Unplaned wood, when sawed in the direction of the grain, often shows marks of varying width and depth from the saw used. In the case of frame-sawed lumber, these marks arise during the upward and downward movements of the frame saw. The variations are caused by inequalities in the setting of the teeth and by variations in the pressure on the wood under the saw. The same conditions hold for wood cut with a circular saw; the marks are more or less curved, depending on the diameter of the saw, and differ from the marks of a frame saw, which are straight but may be more or less oblique with reference to the grain of the wood. These saw marks have special significance in the identification of pieces of wood separated from one another in the direction of the grain.

It can be more difficult to determine, solely with the aid of marks from the saw used, whether two cut-off pieces originally belonged together. If the cutting was done with a hand saw, identification is sometimes possible because the marks of such a saw are often irregular and show characteristic formations. This is connected with the fact that changes in the position of the saw, in relation to the piece of wood, always occur on the forward

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and backward strokes of the sawing arm. Also, after a pause in sawing, the saw never takes up exactly the same position again when restarted. In cutting with a machine saw, the marks are generally regular and meaningless, and therefore cannot generally be used for identification. A transverse section of wood has a poorer power of reproducing marks from a saw than a longitudinal section, owing to the difference in the structure.

If pieces of wood have been painted or surface treated in any way, shades of color may be useful for identification and the pigment can be chemically and spectrographically examined to confirm the agreement or difference between the constituents. There may be several coats of paint and agreement or difference in this respect may be noted.

Any knots or cracks in pieces of wood, as well as drill holes, nail holes, or screw holes, are significant when it is necessary to decide whether or not pieces of wood originally were a unit. Based on nail or screw holes or remaining nails or screws, it is sometimes possible to determine whether a certain piece of wood was previously combined with another piece or formed part of a floor or wall.

If pieces of wood are separated from one another by a break running in the direction of the grain, identity can be determined by fitting the pieces to one another. Certain difficulties are associated with a break going across the grain because the broken surfaces are often badly splintered and a number of fibers may have fallen away and been lost.

Chips and Splinters of Wood

Considerable quantities of chips or splinters may be found at the scene of a forced entry. They are usually examined in order to find marks from the tool used to gain entry. Chips of wood can also be valuable in the identification of the tool in another way. Mixed in with chips from the forced doors or windows may be a chip that has broken off the handle of a chisel, hammer, or other tool. A piece from a broken tool handle may be compared later with a tool recovered in the perpetrator's possession. Pieces of wood from the tool may be painted in the same way as the handle of the tool or make a physical match with the tool in jigsaw puzzle fashion.

Sawdust, Wood Meal, or Other Particles of Finely Powdered Wood

Particles of wood can sometimes be found in the pant cuffs, pockets, hat, or gloves, or detected on tape lifts of the suspect's clothes. Clues consisting of these particles may also be left behind at the scene if the clothes of the criminal were contaminated with them and the trace material brought to the scene. In some cases, the species of tree can be determined simply by microscopic examination and the occurrence of any foreign bodies on or together with the particles can be confirmed.

Wood anatomy and identification is a narrow specialty not found in many crime labs. University and U.S. Government experts are available for assistance in such cases.[1]

Plant Material

A wide variety of materials of plant origin may be useful sources of physical evidence. Besides wood, leaves, seeds, bark, twigs, and pollen are sometimes collected as evidence. They may be attached to clothing, found in a vehicle, or present on a weapon (Figure 7.15).

[1] The Center for Wood Anatomy Research, U.S. Department of Agriculture, Forest Products Laboratory located in Madison, Wisconsin, is a good place to start. See http://www.fpl.fs.fed.us/.

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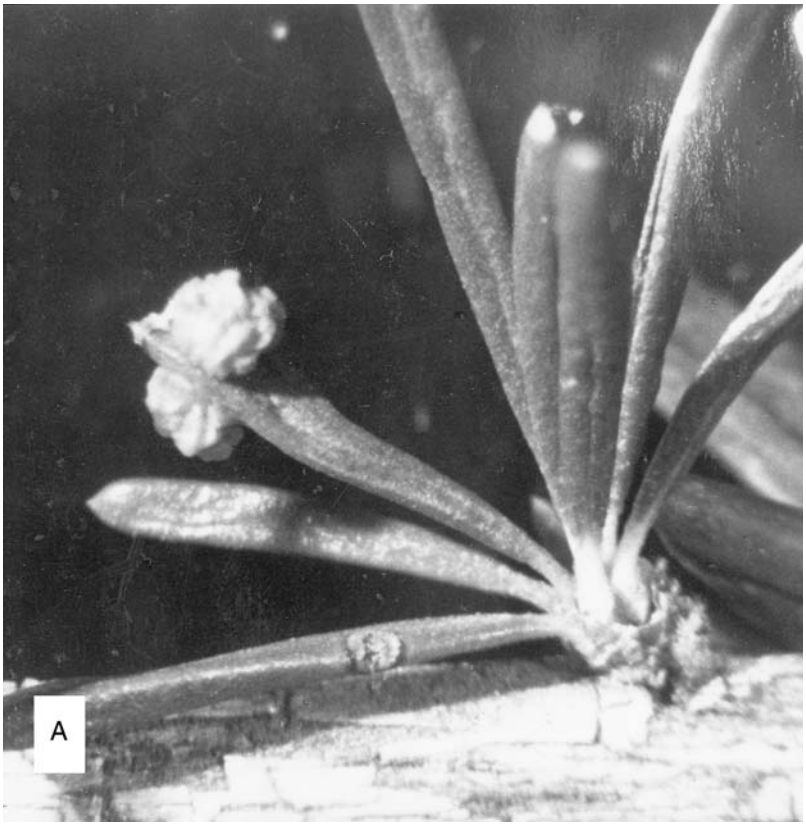

Figure 7.15 A small, fresh fragment of *Adenostoma fasciculata* containing growths on its leaves, which were found to be galls of Eriophyid mites (A), was recovered from a suspect's vehicle. This unusual plant specimen was also present at the location where the victim's body had been dumped. This particular plant only exists at certain elevations on east-facing slopes and only near disturbed environments such as a road. Other plant materials, e.g., pollens (B and C), are sometimes encountered as trace evidence. *(Los Angeles County Sheriff's Department.)*

Fragments of plant material generally require a high degree of expertise to identify. Botanists employed at natural history museums or at a local arboretum may be willing to lend their expertise in the identification of such material.

Pollen is a useful material for determining whether a subject was present in an area where flowering plants are located. Vacuum sweepings of a suspect's clothing may yield microscopic pollen grains whose species can be microscopically identified.[2]

Glass

Glass may be useful evidence in a wide variety of cases. Hit-and-run cases often have headlamp glass or windshield glass present, burglaries frequently involve window glass, and bottle glass is sometimes found in assault cases. Broken glass may yield information about the direction and speed of a projectile and, in the case of multiple projectiles, the sequence of events.

[2] For further information on forensic botany, visit the forensic botany web page at http://www.dal.ca/~dp/webliteracy/projects/forensic/vandommelenst.html

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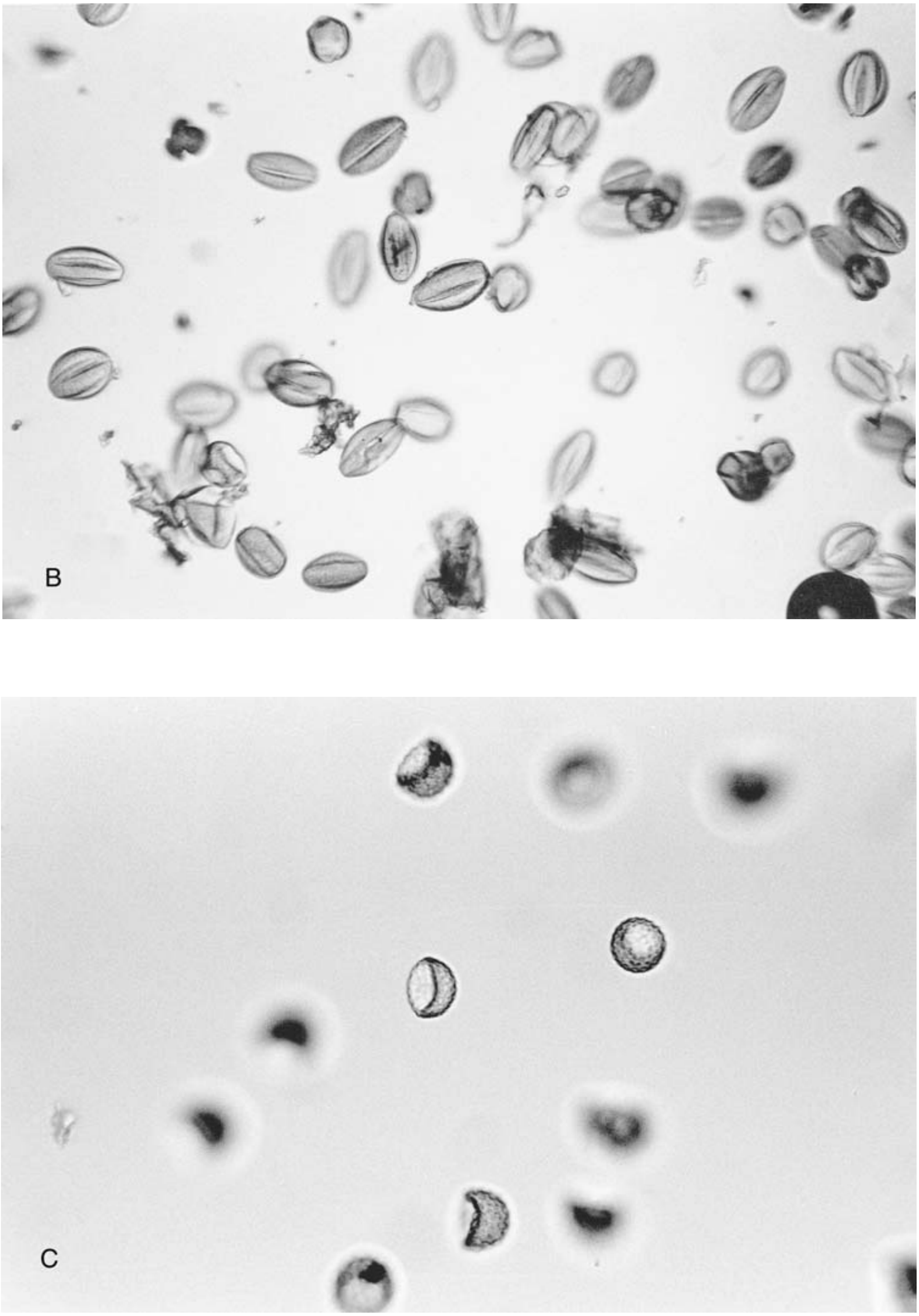

Figure 7.15 (continued)

Broken Panes of Glass

The police investigator often must decide whether a pane of glass was broken from the outside or the inside or if it was struck by a bullet or by a rock. Pieces from the broken

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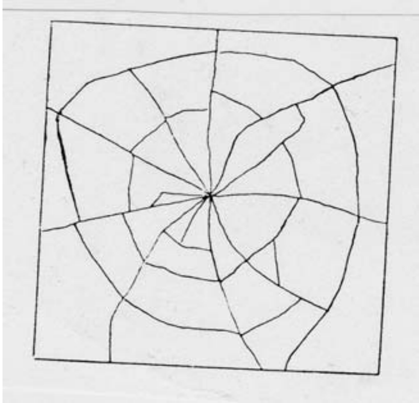

Figure 7.16 Sketch illustrating the radial and concentric fractures in a pane of glass.

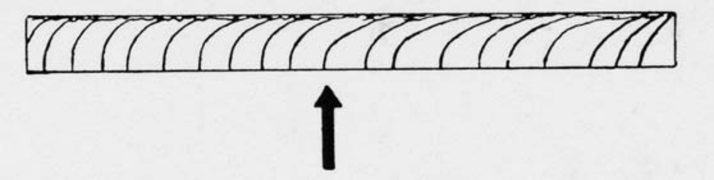

Figure 7.17 Diagram showing the curved lines in the edge of the glass in a concentric fracture. They are almost perpendicular to the side from which force was applied. In radial fractures, the direction is reversed.

pane or the hole often show marks characteristic of the type of injury and the direction of the force. If correctly interpreted, these indications give useful information.

Anyone who examines the edge of a piece of broken glass will note a series of curved lines that form right angles with one side of the pane and curve tangentially with the other side. These fracture lines are a result of force applied to the glass pane and are referred to as conchoidal (shell-like) fractures; they can be used to determine from which direction the force came that caused the glass to break (Figure 7.17).

When an object has been thrown through a glass pane, two types of fractures that form a pattern resembling a spider's web will be seen. These fractures are called radial and concentric fractures. Radial fractures are cracks that start at the center or point from which the object struck the glass and run radially outward or in a somewhat star-shaped pattern from the point at which the break starts. Concentric fractures form concentric circular cracks in the glass around the point of impact (Figures 7.16 and 7.18).

Determining the direction of force becomes a simple matter of examining conchoidal fractures along the edges of radial or concentric fractures. Before drawing any conclusions about the direction of force, the examiner must be certain whether a radial or a concentric fracture is being examined. It is also worthwhile to mark the pane of glass to show the inside and outside clearly.

The determination of the direction of force is accomplished as follows: carefully remove a piece of broken glass, locate an edge that corresponds to a radial fracture and examine it edge wise, noting the presence and configuration of the conchoidal fractures. Observe with which surface of the glass the conchoidal fractures make a right angle; because that

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Figure 7.18 An actual case example of radial and concentric fractures in glass. *(Connecticut State Police.)*

side of the glass is not the side from which the force came, the force came from the opposite side.

The results of concentric fractures are opposite those of radial fractures. In examining the edge of a concentric fracture, the side of the glass forming the right angle with the conchoidal fracture is the side from which the force came. Because of this obvious chance of confusion, it is very important to be able to distinguish between radial and concentric fractures.

With small pieces of glass it is very important not to get the sides mixed up. It is advisable to collect all the pieces of glass and fit them together so that a complete picture is obtained of the broken pane where the force acted. In the case of windowpanes, a useful indication can be obtained from the layer of dirt often present on the outside of the glass.

Definite conclusions should be drawn from the curved lines of the edge surfaces only in the case of fractures that lie nearest to the point of attack. Solely with these closest fractures can one be sure that the conchoidal fractures resulted from the break in question. Fractures at a greater distance from the point of attack may have been produced, for example, when the object used for breaking the glass was brought back, or by projecting and interfering points of glass being broken off by hand.

When glass is transported to the laboratory for examination, the pieces should be carefully marked and individually wrapped in paper. The wrapped evidence may then be

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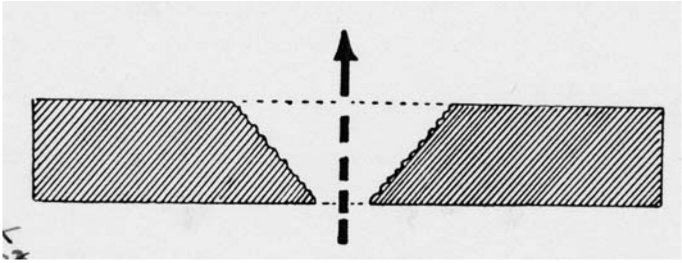

Figure 7.19 Diagram showing formation of a bullet hole in a pane of glass. Note the crater form of the hole. The arrow shows the direction of the shot.

placed together into a box for easier transportation. Packaging should be done to minimize breakage.

Glass Perforated by a Bullet

If a bullet perforates a pane of glass, the hole is expanded in a crater on the side where the bullet exited the pane. The location at which the cone-shaped crater is narrowest indicates the direction from which the bullet was fired (Figure 7.19).

The appearance of the hole can indicate the velocity of the projectile. High-velocity bullets leave an almost circular hole in a pane of glass without noticeable cracking or with cracks merely starting. Lower velocity ammunition leaves an almost regular polygon with radial cracks running outward.

A shot at very close range more or less completely shatters the glass from the pressure of the muzzle gases; the extent depends on the power of the cartridge and the thickness of the glass. In such cases, it is impossible to obtain a clear idea of the appearance of the shot hole unless the shattered splinters of glass can be pieced together. In most cases this is not possible because the splinters from the parts nearest the actual hole are too small. In a very favorable case, indications of the metal of the bullet on the edges around the hole may be detected spectrographically. A reliable indication that the glass was shattered by a shot at close range is the presence of gunshot residue particles on the glass.

It is sometimes difficult to determine whether a hole in a pane of glass was caused by a bullet or by a stone that was thrown. A small stone thrown at relatively high speed (such as one flung by the action of a tire of a passing car) can produce a hole very similar to that caused by a bullet. However, the crater-like expansion of a hole caused by a small stone may not show the same uniform, conchoidal fracture in the glass as a bullet hole would. Furthermore, holes caused by small stones generally do not show the same geometrical regularity in the radial and concentric cracks in the glass around the hole as that usually shown by a bullet hole. On the other hand, a large stone can shatter a pane of glass in a manner that nearly resembles the results of a close-range shot. Thus, a careful search for the projectile is necessary to determine the cause of the break.

If a number of breaks are in a pane of glass, it is sometimes possible to determine the order of events producing the holes. Radial cracks produced by the first incident stop by themselves or run to the edges of the glass. On the other hand, cracks from subsequent incidents stop when they meet a crack already present in the glass as a result of earlier fractures. Even when the damage is extensive and large portions of glass have fallen away, the order of the damage can often be established by fitting the pieces together.

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Cracked or Burst Panes of Glass

If a pane of glass has been cracked by the action of heat, it shows characteristic long wavy fractures. Pieces that have fallen out are generally found in the same direction as the source of heat. If a limited area of the glass has been exposed to a direct flame, a piece of glass corresponding to that area often breaks off.

Automobile safety glass breaks completely or partially into pieces or small rods of a regular form when subjected to a violent blow or shock. Automobile manufacturers use tempered glass intentionally because it lessens the chance of being cut by flying glass.

A pane of tempered glass shattered by a bullet may still remain hanging in position on the vehicle. In a typical crackle pattern, the crack formation extends over the whole pane, but close around the point of fracture a large number of small pieces of glass usually come loose and fall away; thus a study of the crater formation in the glass is possible only in rare cases. If pieces that have fallen out are found, however, in favorable cases, they can be pieced together in their places near the point of impact and the appearance of the fracture can be reconstructed.

If a few small pieces believed to be tempered glass are found at the scene of an accident, a simple test can determine whether the glass is in fact tempered. Interference patterns caused by strain in the glass are easily observed by examining the glass with polarized light. A specimen of glass is placed over a light source with a polarizing filter. The glass is viewed with a second polarizing filter and a characteristic pattern is observed, indicating tempered glass.

Glass Splinters

At a scene where the criminal has obtained entry by breaking a window or glazed door, the investigating officer should always remember to collect pieces of glass for comparison purposes. If a suspect is found at a later time, a careful examination of the clothing may show splinters of glass. Glass splinters may also be found in the handle of a tool used to force entry into a building (Figure 7.20).

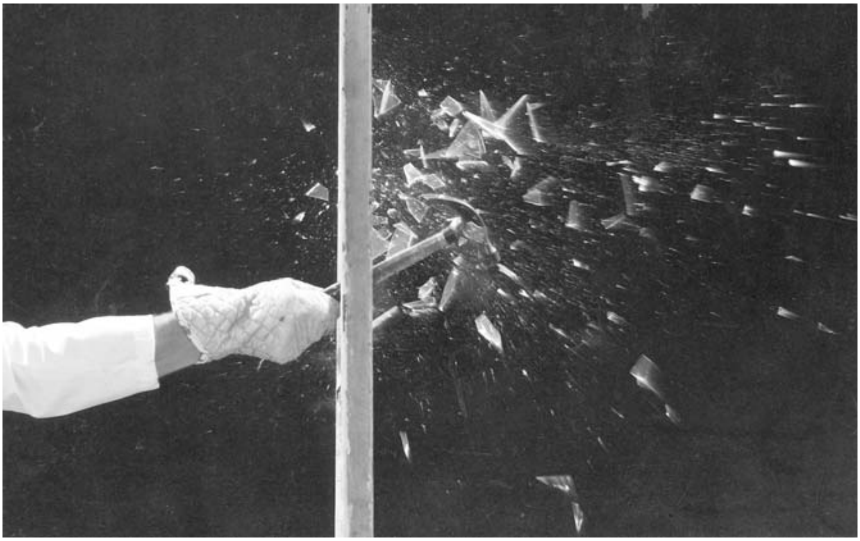

Figure 7.20 A burglar may be linked to a window he has smashed by the tiny fragments of glass that fly backward onto his person and clothing. *(Center of Forensic Sciences, Toronto.)*

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When such splinters of glass are found on a suspect's clothing or tools from a burglary investigation, they will usually be too small to make a direct physical comparison against the pane of glass from which they possibly came. However, a number of other comparisons can be made to show a common source between the exemplar and questioned glass specimens.

Glass evidence may be examined for a number of physical and chemical properties. Density, refractive index, color, thickness, and chemical composition are some of the common characteristics examined to differentiate glass. Such tests will not result in a definite identification because glass is a mass-produced material with wide use. Nonidentity, however, can be proved and this may be useful information.

When known samples of glass evidence are collected as exemplars, several samples should be taken from different parts of the same pane of glass and packaged separately because there may be variation in glass properties in the same pane.

Objects Left at the Crime Scene

Criminals sometimes leave items behind at the crime scene that they believe have no further use. Items may be lost or forgotten by the suspect. The criminal may have been surprised during the act and forced to leave abruptly without picking up personal effects. Items left behind can be extremely valuable to investigators; they may help connect the suspect to the crime in other ways or prove the suspect's identity if fingerprints are present.

Paper

Paper such as newspaper, wrapping paper, and paper bags is sometimes left at a crime scene. Besides trace evidence, handwriting and latent fingerprints may be present. If the paper at the scene is torn or cut, a search of the suspect's home or car may turn up a matching piece of paper that can be fitted together with the evidence. In some cases watermarks or stains on a piece of paper may be used to show a connection to paper located at another site.

Articles of Clothing

Manufacturer's markings on clothing are occasionally of value. The presence of a foreign label in clothing may indicate the nationality of the wearer; however, because a large number of clothes are imported, any conclusion is open to question. Size and laundry marks may be valuable. Size gives an indication of the physical characteristics of the subject and laundry marks may identify the suspect. Other marks such as initials and even names are sometimes found and, of course, are valuable evidence. Hair should always be searched for, as well as other trace evidence. If secretions or dried blood is found on an article of clothing left at a crime scene, the subject's DNA type may be determined. Pockets should be searched as a matter of course. In some cases, useful evidence will be found. Torn pieces of clothing are valuable. If a matching piece of clothing can be found in the suspect's home or car it can easily tie the suspect to the location.

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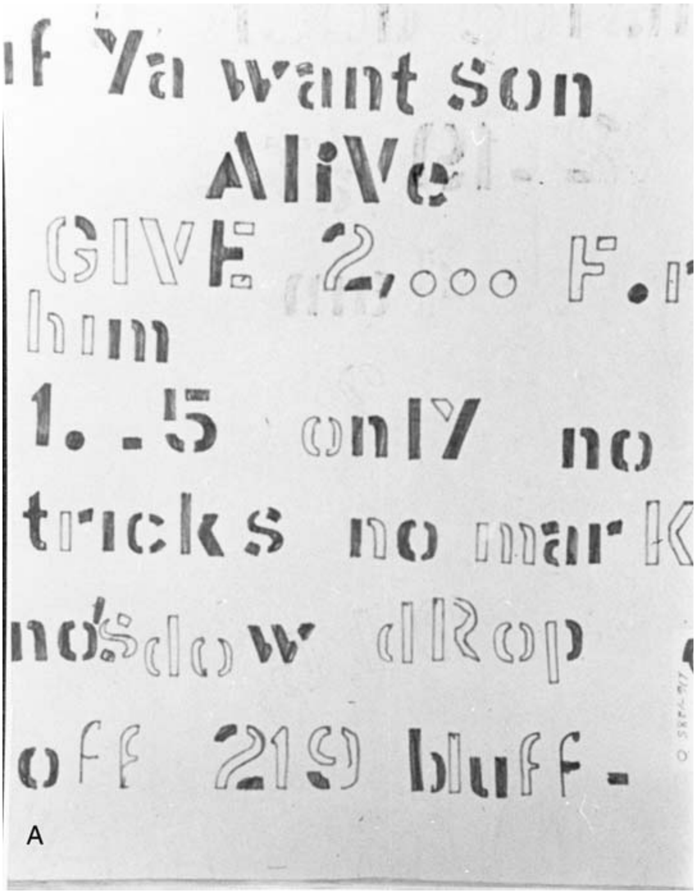

Figure 7.21 A young boy was kidnapped and his parents were sent a stenciled ransom note. The stencil was later found in the suspect's home. (A) is a portion of the note, (B) is a close-up of the word "Ya," and (C) is an overlay of the stencil and the word "Ya." *(Iowa Department of Public Safety.)*

Product Markings

Many commercial products bear manufacturer's marks on the label, package, or container. The markings are used to designate the date, lot number, location of manufacture, and other such details as a control to assist the manufacturer in checking on distribution and sales of the product. The markings may also assist the investigator in determining the origin of products found at crime scenes. Because the markings are usually in code form, the manufacturer or distributor must be contacted to determine the meaning of the information.

Foodstuffs

Foodstuffs in the form of stains or debris are sometimes found as evidence and may be useful in determining the type of work in which a subject is engaged. For example, if vacuum sweepings are examined and a quantity of wheat starch is found, it could indicate that the suspect had been baking. Through careful examination, it is possible to determine the nature of very small samples of foodstuffs through microscopic and microchemical means (Figure 7.22 and Figure 7.23).

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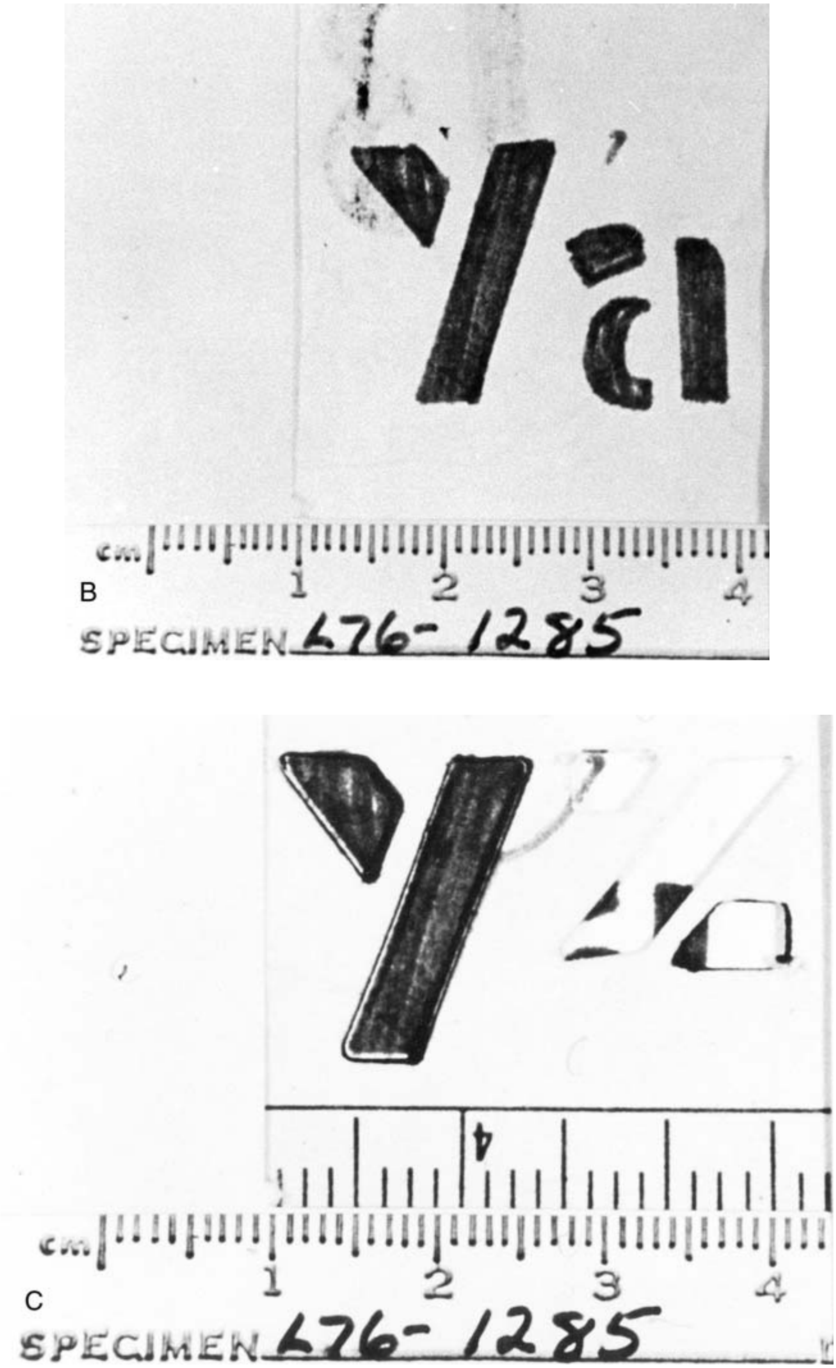

Figure 7.21 (continued)

Cosmetics

Cosmetics such as lipstick, nail polish, and various creams and lotions may sometimes be collected as evidence in cases. If exemplars are available, a laboratory can make a chemical comparison to determine whether the known and questioned specimens share a common

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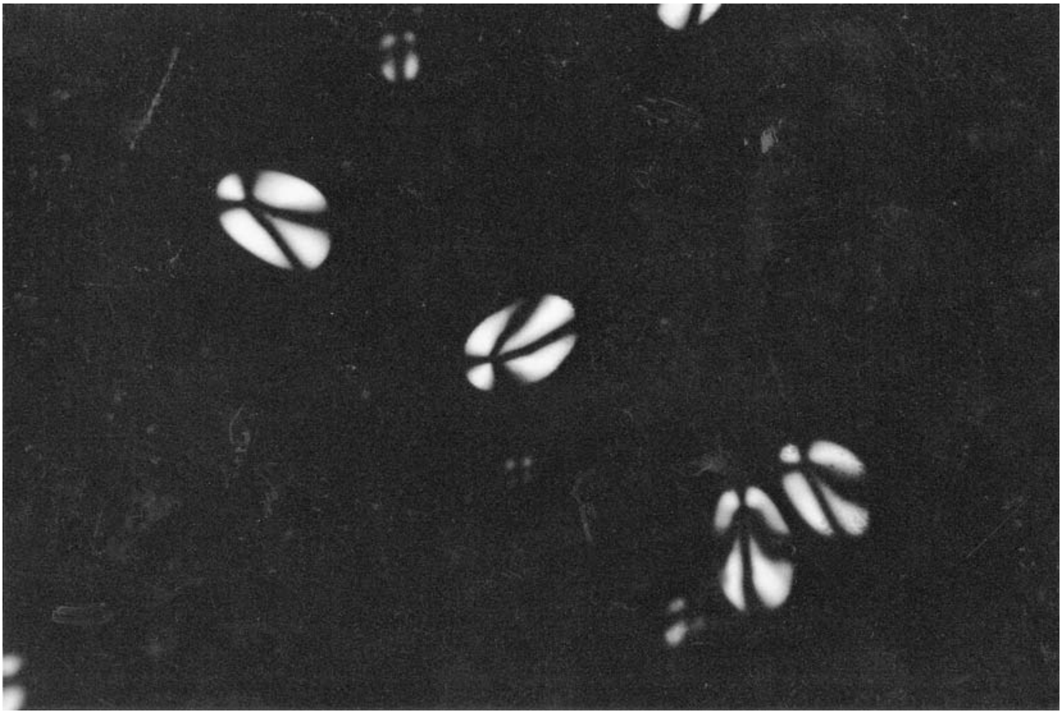

Figure 7.22 Starch has a highly characteristic appearance under polarizing light microscopy. This photomicrograph shows potato starch. *(Los Angeles County Sheriff's Department.)*

source. Cosmetics firms are constantly reformulating their products, so if the brand of the cosmetic can be determined it may be possible to determine the approximate time a given specimen was on the market.

Hair

Hair evidence is generally associated with crimes involving physical contact such as murder, rape, assault, traffic accidents, and other similar crimes. Hair may be found at the crime scene, on the victim or suspect, or attached to a weapon, tool, vehicle, or article of clothing. Because of its small size, hair may be difficult to find. Care and patience are required to conduct a thorough search for this evidence.

Determining if hairs come from a similar source is a controversial subject. The Innocence Project[3] has uncovered cases in which the interpretation of hair examinations has been in conflict with mitochondrial DNA (mt-DNA) testing. Some examiners now suggest that microscopic evaluation of hairs collected from crime scenes should be additionally examined using mt-DNA testing and that hair testing results are best reported using the two procedures to complement one another.[4] If DNA testing is not possible, the most positive statement that microscopic examination of hair can offer is that the hair did not come from a specific individual.

[3] See http://www.innocenceproject.org/

[4] Houck, M.M. and Budowle, B., Correlation of microscopic and mitochondrial DNA hair comparisons, *J. Forensic Sci.*, 47(5), 2002.

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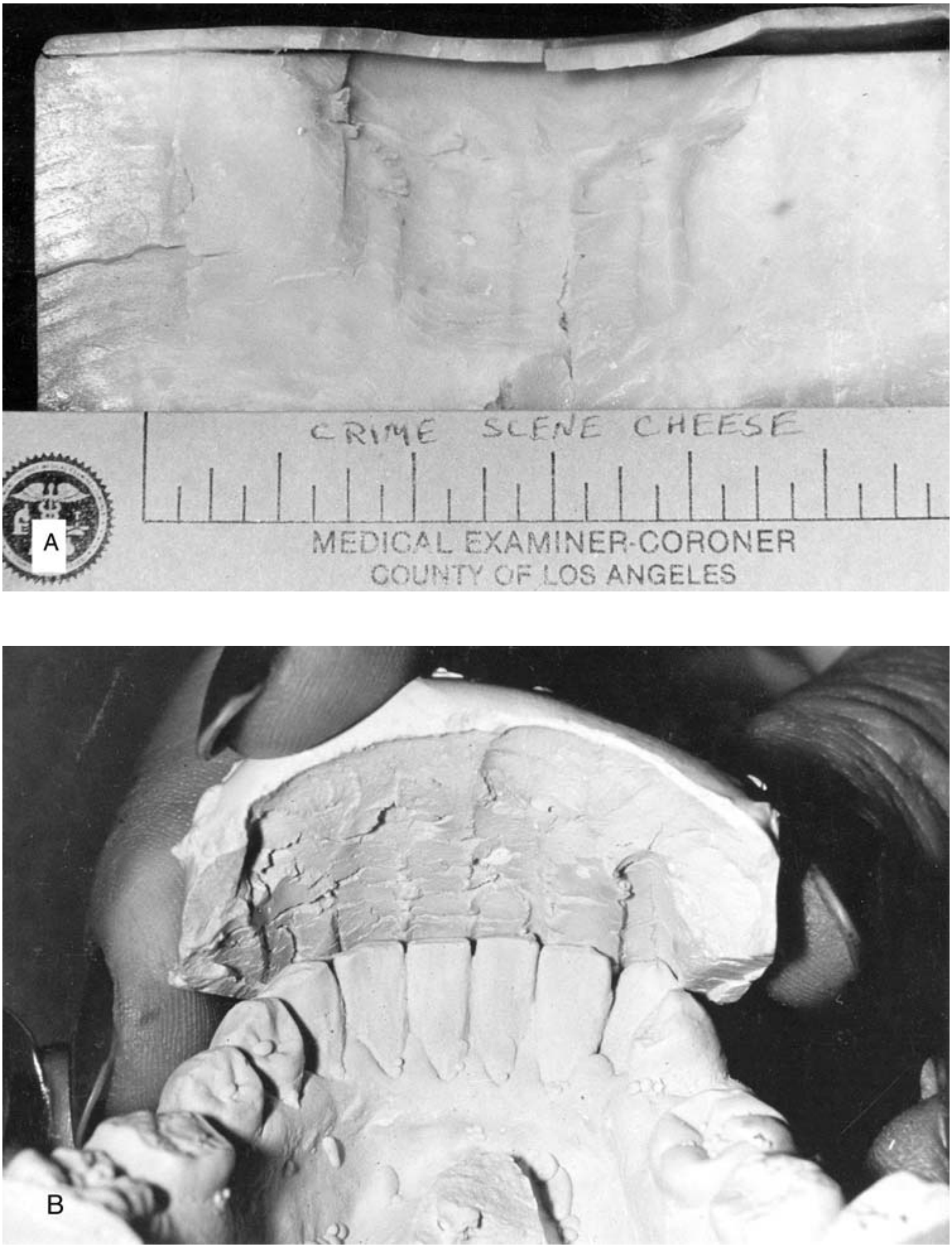

Figure 7.23 Bite mark in cheese found at a crime scene (A) is compared with a dental impression of the cheese and the suspect's teeth (B). *(Los Angeles County, Department of Coroner.)*

Reports stating that the known and exemplar hair specimens are "similar and may have come from the same person or a person with similar hair characteristics" only beg the question. A forensic examiner is not able to provide the degree of certainty to a statement of similarity and laypersons may incorrectly conclude that the term "similar hair characteristics" is far more significant than it actually is.

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The remainder of this section concerns microscopic and morphological examination of hair. Although such examinations can exclude a suspect hair, they cannot positively prove that a sample came from one and only one person. If the hair strands found at a crime scene and those of a subject show similar characteristics, the strongest statement that can be made is that the subject could not be excluded as the donor of the hair. The hairs could have come from that subject or any other individual with similar characteristics. A statement about probabilities of a given hair coming from a specific person is not appropriate at the present state of the art of hair examination in criminal cases.

Even though it is not possible to determine the person from whom a strand of hair came, there is probative value in hair examination. Information such as species, location of growth on the body, hair treatment, hair disease, and whether hairs fell out naturally or were forcibly pulled can be determined.

When conducting a hair examination, the criminalist first attempts to determine whether the hair evidence is animal or synthetic in origin. Microscopic examination of a hair quickly determines whether the evidence is animal, synthetic, or simply a plant fiber. Furthermore, it is possible to determine whether the hair is human or animal in origin and, if animal, the species of the animal. Domestic animals such as dogs, cats, cows, and horses are somewhat common. Hairs from wild animals are sometimes collected at crime scenes, e.g., at the scene of skeletal remains. It is not possible to determine whether two hair specimens come from a specific animal. Although differentiating between human and animal hair is not difficult, determining the species of animal requires a greater degree of expertise from a hair examiner. The ability to ascertain this is determined by the experience of the individual performing the analysis.

In addition to determining that a specimen of hair is human, it is usually possible to determine whether the hair is from the head or another part of the body. At one time it was possible to draw a conclusion about the gender of an individual based on the length of a hair strand. Present hairstyles no longer make that deduction valid.

Examination of hair may indicate that it was chemically treated. Hairs that have been bleached, dyed, straightened, or otherwise treated can be compared with specimens from a subject to determine whether the subject's hair has been treated in the same way. Sometimes, hair shows the presence of lice or fleas, which can be useful as a means of comparison. Microscopic examination of the hair root may indicate that the hair was forcibly pulled out as opposed to falling out naturally. Such information may be used to indicate a struggle.

Case

In the prosecution of a rape case, the sole issue was consent. The law defines rape as "nonconsensual sexual intercourse." The defendant claimed that the victim voluntarily consented to sexual intercourse, but the victim testified that she was forced to comply. Head hairs matching the victim's were examined. The hairs were forcibly pulled out. This information was used to corroborate the victim's testimony.

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If hair is forcibly pulled out, an additional bit of information may be obtained. It is possible to determine the DNA type of an individual from sheath cells found on hair roots. These cells are present only when hair is pulled out, not if it falls out naturally. Another possible test using sheath cells is to determine the gender of the person from whom the hair came.

Searching for hair at the crime scene is a tedious process. Subjecting the floor, furniture and other objects to a very thorough examination is necessary; a flashlight and pair of tweezers are suggested for this purpose. Hair found on an object or in a certain location may be folded in a clean sheet of paper and placed in a properly labeled envelope. Detailed notes should be made to indicate the date, time, and location of the hair. A sketch or photograph of the area should be made. When a number of hair samples are collected from the same location at the crime scene, sorting the specimens is not recommended. They should be submitted to the crime laboratory for careful and expert examination. If several hairs from different locations are collected, it is important not to package them together. Confusion will arise if the hairs are different and in the same package.

Hair evidence is frequently found on the body of a victim. Pulled-out strands of hair may be found clutched in the hands or under the fingernails of a murder victim. A rape victim sometimes has her assailant's pubic hair present on her body or the bed or location where she was lying.

Pubic hair combings in rape and rape–murder cases are a routine way of collecting hair evidence. It is advisable to collect hair as well as other types of evidence associated with these cases as soon as possible. Trace evidence such as hair is quickly lost unless gathered promptly.

Clothing belonging to the victim of a murder, rape, or assault should be examined for hair evidence. Hairs may become entangled among threads of the fabric. Generally a very careful examination of the clothing is necessary to locate hairs.

In order to examine hair evidence collected in an investigation fully, it is necessary to obtain exemplars from the individuals involved. In some instances, a court order may be required to obtain hair specimens from a defendant. It is strongly recommended that if there is any doubt or question, the investigator contact the prosecuting attorney for a ruling. It is better to make the extra effort in obtaining a court order to secure the evidence than to run the risk of having valuable physical evidence excluded from the trial because it is found to be inadmissible.

Hair specimens should be gathered from the entire body — head, face, chest, arms, pubis, legs, etc. Sufficient numbers of hairs should be taken from each location. Pulling or plucking is the preferred way to collect hair. Head hairs should be collected from several different areas of the head. Specimens should be taken from the front, back, left, right, and top areas. About 25 hairs should be collected from the head. The reason for the large number is because hair varies so much even on the same person. A close inspection of a person's head hair will clearly show several different shades and even colors on a given subject. Thus a large sampling is desirable.

The investigator, criminalist, or hospital personnel may collect hair. The easiest method of collecting the specimens is to let the subject pull the hair and place it into a properly marked envelope. It is important to package hairs collected from different parts of the body separately.

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Feathers

On rare instances feathers may be collected as evidence in an investigation. Most crime laboratories have very little or no expertise in analyzing this type of material. Feathers should be collected if discovered and may be identified by experts at museums or academic institutions.[5]

Electrical Wire

Insulated electrical wire is sometimes collected as evidence. The wire may have been used to tie up a victim of a crime or it is sometimes attached to a car stereo or tape deck stolen from a vehicle. In both cases it may be possible to show that one end of the wire was once part of another end.

Generally, electrical wire that has many strands does not lend itself to tool mark examination. The wires are so fine that sufficient markings are not imparted onto the wire from the tool. If the wire is of a thicker gauge, it may be possible to examine extrusion marks on both ends to determine if each of the pieces has the same class characteristics.

Extrusion marks will also be present on the wire insulation. Because the insulation has a greater surface area, it is easier to work with that portion of the evidence. The extrusion markings along with the cut edge, which sometimes can be made to fit the other piece of wire evidence, can lead to the conclusion that the wires were once from the same continuous piece.

If a positive fit cannot be made, physical characteristics such as the number of strands of wire, the gauge, the appearance of the break, and the color and markings on the insulation may be used at least to show that the wire was of a similar manufacture. Whatever type of examination is made, it is always necessary to have an exemplar to compare with the evidence wire in order to make a conclusion.

Broken Tools

Broken tools are frequently discovered at burglaries of safes and breaking-and-entering cases. Broken ends from screwdrivers, wrecking bars, and metal punches are important types of physical evidence. Their usefulness lies in the fact that, if the remaining part of the tool is discovered, a positive statement can be made that the piece found at the scene and the tool were once intact.

Broken knives are another kind of tool found at crime scenes. A piece of knife blade may be discovered at the scene of an assault or murder or be present in the wound of a victim. If the other part of the knife can be recovered, the two parts can be physically fitted together (Figure 7.24).

In addition to the fit, a microscopic examination of the knife and the broken piece of blade usually shows fine scratches caused by wear and use on the flat surface of the blade. These markings run continuously through the area of the break and can conclusively show that the broken piece and the blade were once a continuous piece.

[5] For an overview of forensic ornithology see: http://www.ummz.lsa.umich.edu/birds/WOSManual/4.ForensicOrnithology.pdf

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Figure 7.24 A piece of a broken knife blade (A) was recovered from a crime scene and matched to a knife found in the suspect's possession (B and C). *(Los Angeles County Sheriff's Department.)*

Tape

Electrical, adhesive, masking, and cellophane tape are sometimes recovered at crime scenes. The tape may have been used to bind a victim or to tape two objects together. If a roll of tape is located in the suspect's belongings, it may be possible to piece together the portion of tape from the scene and that found in the suspect's possession. If the tear at the end of

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Figure 7.24 (continued)

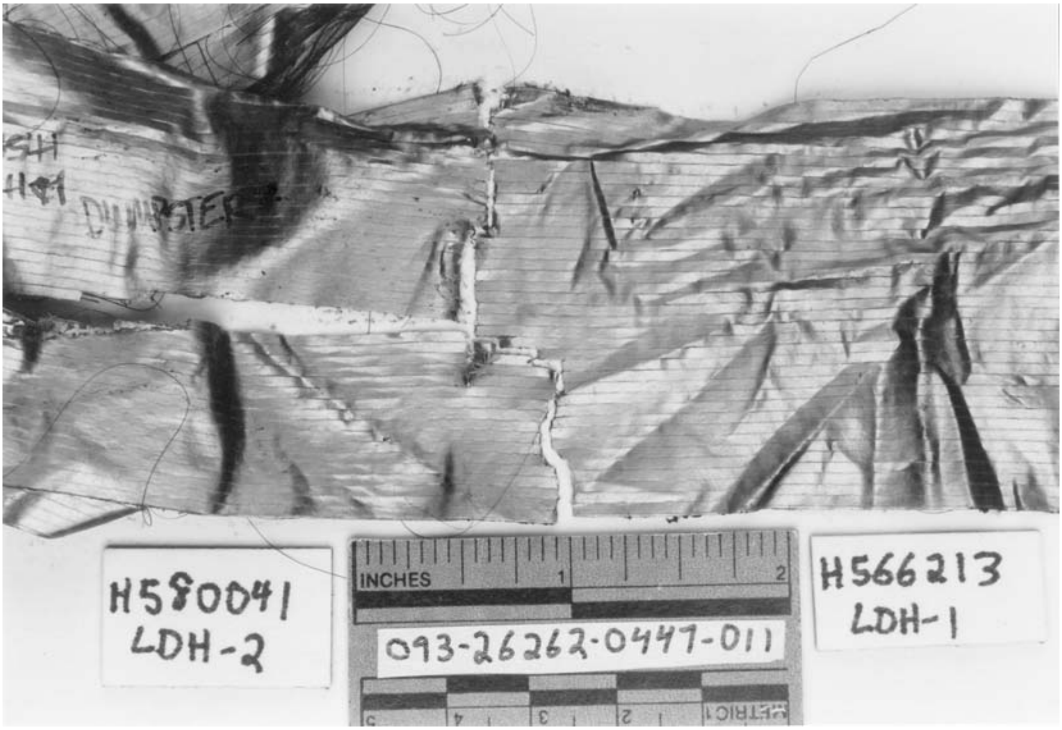

Figure 7.25 (A color version of this figure follows page 256.) Duct tape is often used to bind victims. In this case, tape removed from the victim was matched to a roll found in the suspect's home. *(Los Angeles County Sheriff's Department.)*

the tape is ragged enough, a conclusive statement about a common source may be made. If the cut on the tape is very sharp, such as that made by scissors, only a statement about class characteristics can be made (Figure 7.25 and Figure 7.26).

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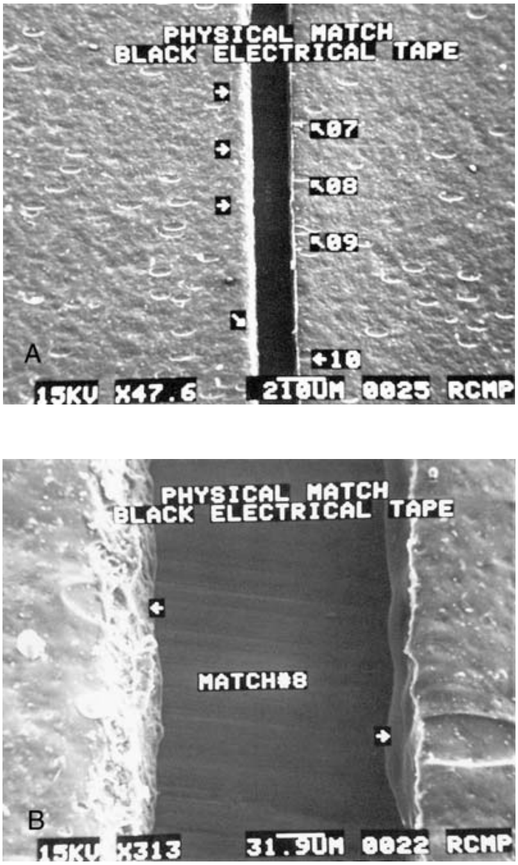

Figure 7.26 Photomicrographs of a physical match of cut electrical tape from a drug case. (A) shows the cut tape edges and the markings (pits) created in the manufacturing process. The arrows illustrate pits that were cut through when the tape was cut. (B) is a magnification of the previous photograph. *(Royal Canadian Mounted Police, Forensic Laboratory Services.)*

Headlamps

Headlamps from automobiles and other motor vehicles are routinely submitted to crime laboratories in traffic accident investigations. A careful examination of the headlamp filament can help determine whether the lamp was on or off at the time of the accident. The traffic investigator should be aware of this possibility and collect any pieces of broken headlamp, tail lamp, or other debris present at the scene of the accident.

Computer Seizure[6]

When encountering a computer or any type of computer equipment or data devices (disks, tape cassettes, etc.) at a crime scene, the most important thing to remember is: do not be in a hurry! Unless a suspect is destroying something in front of your eyes (which does happen, but only in rare cases), you can safely assume that the evidence is not going anywhere.

[6] This material has been adapted from the Los Angeles County Sheriff's Department Forgery Fraud Detail, Computer Crimes Unit.

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The most common way computer evidence is destroyed is from mishandling seized equipment. Some of the ways this happens are:

- Investigators become impatient and want to look at data by using the normal start up and access procedures without considering the possibility of computer booby traps set by suspects, which may destroy data.
- The nonexpert uses common software to start up the equipment. The software has properties that destroy the data.
- Equipment (hardware and/or software) is mishandled at the crime scene or en route to the lab by improper evidence packaging or transportation.
- Unauthorized persons get involved in looking at evidence through curiosity or a haphazard request — the "*Hey, Fred, do you know anything about computers?*" syndrome.

You do not need to be an expert to seize a computer, but you should consult an expert. You will need experts to analyze and locate relevant computer data for you and your case properly and *legally*. Data and computer equipment must be treated like any other seized evidence. Keep chain of evidence procedures in mind.

Steps to Remember

- Call your agency's computer crimes unit or other appropriate experts for advice prior to seizure.
- When approaching computer equipment at a crime scene, clear everyone away from the equipment and do not allow anyone to touch any of the equipment.
- With stand-alone computers (computers without network cables), pull the power cord to turn them off. Do not touch the keyboard or any of the switches!
- If the system involves a network (computers hooked up in a series to each other or to a larger computer), do not unplug them. Call your agency's computer expert before proceeding.
- If possible, take photos of the front and rear of all computers (where cables are attached).
- Before disconnecting any cables, label all connectors and computer connections with numbers or letters. Disconnect as few cables as possible. It may be necessary to disconnect some to avoid unsafe or heavy lifting; but usually one end of a cable can be disconnected, leaving the other end attached to a device.
- Attach an evidence tag to each individual piece of equipment and properly label it with the brand name, type, and model and serial numbers.
- Place all seized diskettes, tape cartridges, etc. in labeled evidence envelopes. Do not write on the diskettes. Keep magnetic storage media away from magnetic fields. Do not store in a hot area such as the trunk of a car.
- Document where all items were found at the location and who found them.
- Leave an inventory receipt form with persons at the location.
- Transport equipment in an enclosed vehicle. Avoid pick-up beds and car trunks. If possible, use boxes and car seats or a van.
- Store equipment in a safe place where it is out of the way and will not be tripped over or stepped on.

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Collecting Videotape Evidence[7]

The utilization of video surveillance technology is a commonplace occurrence today. Video is used in savings and loan institutions, banks, and stores for reducing robberies, shoplifting, and other crimes. It is also used for monitoring public areas in casinos, sports arenas, and parking lots. Law enforcement uses include undercover operations, emergency and disaster responses, media releases, and crime scene recording, to mention just a few. Of course, the home video camera plays a significant role not only in television comedy shows but also in periodically recording unusual and occasionally provocative incidents. The following information is provided as a standard procedure for handling, securing, and protecting video information so that maximum investigative utility may be obtained from it, the odds of conviction enhanced, and investigator's time and effort minimized.

Determine if There Is a Videotape

One of the first questions asked by investigators responding to the crime scene should be, "Is there a videotape of the incident? Where are the cameras? Where are the recorders?"

Stop the Recorder

Often recorders continue after a crime has been committed; therefore, one of the first things to be done at the crime scene is to stop the recorders to avoid accidentally recording over the information captured.

Confiscate the Tapes Immediately, Taking the Usual Chain-of-Evidence Steps

When handling videotape evidence, first stop the recorder but do not eject the tape. It is important to take the time at this point to be sure you know how to stop and eject the tape without accidentally restarting the recording. Next, note the time on the recorder and simultaneously note the time on your watch. Do this to the highest accuracy possible, i.e., to the second. Often the time on your watch and the time on the recorder will not be the same. Therefore, this time discrepancy may be needed and may be important in subsequent analysis. Also note any time differences with any other clocks in the vicinity that may have been noticed by witnesses. Next, note the position counter on the tape recorder. (Times on recorders are notoriously incorrect — they have been known to be off by hours.) Rewind the tape and note the position of the counter again. The difference between the position of the counter number prior to and after rewinding will facilitate the repositioning and analysis of the tape later. Now, carefully eject the tape. Next, write down the information about the recorder. Note the manufacturer, the model, the time-lapse mode and any other recorder settings.

In addition to locating video equipment at the scene of a crime, look for additional videos that may have a view of a crime (perhaps down the street from the scene) and may contain, for instance, the car driving away. For example, when a crime occurs at a mall, convenience stores or bank ATM videos may record suspects entering or leaving the crime area. In addition, suspects may have been in other nearby locations, for instance, streets used for entry or exit routes. Also, it may be useful to look at tape recordings made earlier

[7] This material has been adapted from the National Law Enforcement and Corrections Technology Center — Western Region, El Segundo, California.

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than when the crime occurred because sometimes suspects may have visited the location prior to the crime. If other tapes are located, the collection procedures mentioned previously also apply to them.

Document the Video System's Physical Relationship to the Crime Scene

Write down the location of the cameras and their views in the report or diagram or photograph this data. Additionally, size (height, depth, width) of reference objects in the scene should be measured so that they can be utilized to determine physical dimensions of other things such as the height of a suspect.

Protect the tape! Most tapes have a "write-protect" tab. Break off this tab so that the tape cannot be recorded over.

Now that you have a tape, what is the best procedure? Although it is often compelling, do not play the tape; take it somewhere to be copied and play only the copy, thereby saving the original for laboratory analysis. The reason this procedure is recommended is that often the tapes are old and playing a tape will degrade it. If you have gone to the trouble to collect this tape as evidence, it should be prudently handled. Pausing or slow-motion viewing degrades the tape more. In addition, time-lapse video may not be viewable on ordinary tape recorders. From a video surveillance analyst's perspective, the most common errors are:

- A tape that has been paused on the critical image for a long period of time for study and is thereby ruined for forensic analysis
- Only a portion of a tape analyzed but additional or corroborating information appears in earlier parts of the tape

Make certain that the original tape is secured as evidence and stored where it will not be damaged by magnetic fields such as electric motors, solenoids, and magnetic metal detectors. Also, take care that the tape does not overheat, e.g., do not leave it in a hot car. Store in a cool, dry location. Excessive heat and humidity will cause deterioration.

Seek Technical Assistance if Problems Occur

Any of the National Law Enforcement and Corrections Technology Centers may be contacted for advice and assistance if needed. Also, the FBI has the capability to perform videotape analysis and many of the larger criminalistics laboratories around the nation are available for consultation, guidance, and assistance.

What can be expected from the analysis of video recordings? They can show the crime scene, they often provide a synopsis of a crime and/or a description of a crime scene that would be hard to describe in words or testimony alone. The video is physical evidence similar to a photograph. It may provide images of actions, statements or other physical evidence that may be part of a crime (handgun, rifle, knife, car) and it provides a format for which associate evidence may be used to establish connection between a crime scene and an individual — for instance, the car at a crime scene compared with a car of a suspect, or shoes observed on a person on the video of a crime compared with shoes of the suspect. Not only might it show a connection between a suspect and a crime, it might also provide an alibi for innocent individuals. In addition, video (even stop-action video) can be used to show action in a fashion from which intent may be inferred. For instance, motion video

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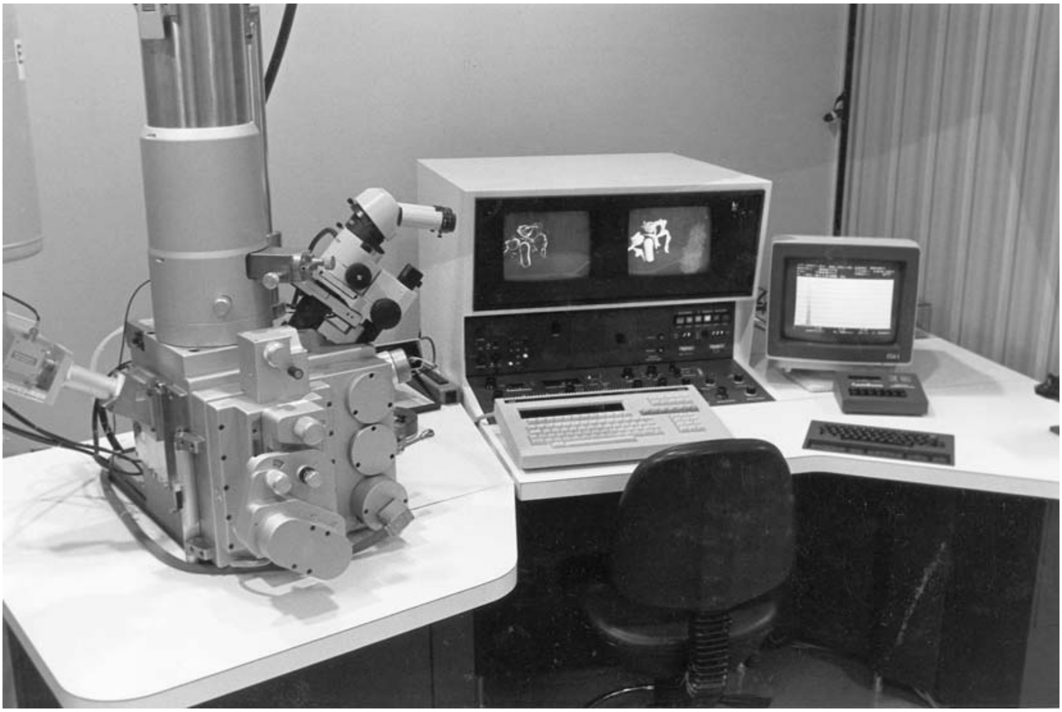

Figure 7.27 The scanning electron microscope (SEM) is an important laboratory tool in today's modern crime laboratory. *(Los Angeles Police Department, Scientific Investigations Division.)*

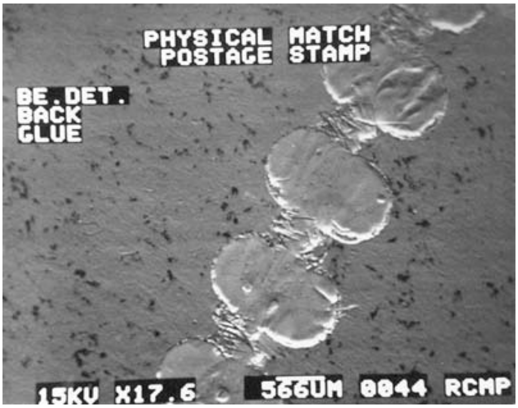

Figure 7.28 Photomicrograph of a physical match of postal stamps in a fraud case, showing a physical match between two stamps. *(Royal Canadian Mounted Police, Forensic Laboratory Services.)*

of a person can reveal vigor of actions (pace), emotions, or other outward indicators of his or her state of mind, not simply identity as a still photograph does.

Preparation and planning are the keys to success in any endeavor and certainly this is true in gathering technical evidence from video surveillance equipment. Well-prepared technicians knowledgeable in the procedure can make the best use of a powerful tool.

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Other Trace Evidence

The scope of trace evidence is such that anything of a small or microscopic size can potentially be trace evidence. It is impossible to detail each and every conceivable type of trace evidence that investigators will come in contact with during their careers. The general rules about evidence collection can be applied to trace evidence:

1. Collect the evidence in a legally admissible way.
2. Package the evidence to preserve it properly.
3. Package the evidence to avoid loss and contamination.
4. Use common sense!
5. When in doubt, contact your crime laboratory.

Remember: only through a careful and patient crime scene search can trace evidence be effectively used in a case.

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8 Blood and Other Biological Evidence

Ever since Cain slew Abel,[1] blood has been invaluable as physical evidence. Indeed, it can be said that of all the significant advances made in forensic science during the past decade, forensic biology has made the greatest strides. Blood is present at most crimes involving violence. It can be used to determine the sequence of events in a crime and tie a suspect to a crime scene. Today, forensic DNA typing has a significant impact on violent criminal investigations and has revolutionized the ability to identify criminals through national DNA offender databases.

A Word of Caution!

Before discussing any testing procedures concerning blood and other biological fluids, some remarks are appropriate about the dangers of blood-borne diseases, e.g., hepatitis, tuberculosis, and AIDS. Individuals working around wet or dried blood at crime scenes, autopsies, and in crime laboratories where whole blood or other biological specimens are present are advised to exercise appropriate care when handling these substances. Appropriate care is also referred to as universal precaution.

Universal Precautions[2]

1. **Barrier protection** should be used at all times to prevent skin and mucous membrane contamination with blood, body fluids containing visible blood, or other body fluids. Barrier protection should be used with ALL tissues. The type of barrier protection used should be appropriate for the type of procedures performed and the type of exposure anticipated. Examples of barrier protection include disposable lab coats, gloves, and eye and face protection.

[1] "And He said, 'What hath thou done? The voice of thy brother's blood crieth unto me from the ground.'" Genesis 4:10.
[2] These precautions are taken from the National Institute of Environmental Health Sciences, National Institute of Health. See their web site at: http://www.niehs.nih.gov/odhsb/home.htm

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2. **Gloves** are to be worn when there is potential for hand or skin contact with blood, other potentially infectious material, or items and surfaces contaminated with these materials.
3. Wear **face protection** (face shield) during procedures likely to generate droplets of blood or body fluid to prevent exposure to mucous membranes of the mouth, nose and eyes.
4. Wear **protective body clothing** (disposable laboratory coats [Tyvek]) when there is a potential for splashing of blood or body fluids.
5. **Wash hands or other skin surfaces** thoroughly and immediately if contaminated with blood, body fluids containing visible blood, or other body fluids to which universal precautions apply.
6. **Wash hands immediately** after gloves are removed.
7. **Avoid accidental injuries** that can be caused by needles, scalpel blades, laboratory instruments, etc. when performing procedures, cleaning instruments, handling sharp instruments, and disposing of used needles, pipettes, etc.
8. Used needles, disposable syringes, scalpel blades, pipettes, and other **sharp items are to be placed in puncture-resistant containers** marked with a biohazard symbol for disposal.

Persons who routinely work with blood and blood products should consider receiving hepatitis vaccinations. Although these shots do not protect against hepatitis C, they are a useful precaution.

Surgical gloves should be worn when working with any biological products: blood, saliva, semen, etc. Smoking, eating or drinking in areas that contain these items is not to be permitted. When specific questions arise about proper handling of biological evidence, crime laboratory forensic biology personnel are good resources, as are local public health authorities. Working around biological samples of unknown sources has a potential risk. However, with appropriate care and caution, those risks can be minimized.

Guidelines for handling biological materials should be posted and discussed with personnel who must handle these materials. Periodic briefing to remind personnel how to handle this type of evidence is important. Appropriate procedures must be taken for disposal of biological evidence. Commercial disposal companies that specialize in biohazard disposal should be used to destroy such materials.

The consequences of accidents, unsound practices, or simply a cavalier attitude can be disastrous. Communicable diseases pose a life threatening danger to employees, their families, and friends. The best practice is to be aware and to exercise care at all times.

Bloodstain Pattern Recognition[3]

Bloodstain pattern evidence is often present at crimes of violence. The shape and distribution of blood drops can assist in reconstructing how the crime occurred.

[3] The International Association of Bloodstain Pattern Analysts is an important professional association for those who routinely evaluate this type of evidence. Their web site is located at: http://www.iabpa.org/. The International Association for Identification offers a bloodstain pattern examiner certificate. See their web site at: http://www.theiai.org/certifications/bloodstain/requirements.html.

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The shape and appearance of bloodstains and smears can give useful information about the crime. In 1971, MacDonell[4] published his classic work on blood stain pattern evidence and outlined several general rules regarding bloodstain evidence:

1. *Spots of blood* may be used to determine the directionality of the falling drop that produced them. Their shape frequently permits an estimate as to their velocity and/or impact angle and/or the distance fallen from source to final resting place.
2. *The diameter of a blood spot* is of little or no value in estimating the distance it has fallen after the first 5 or 6 feet. Beyond this distance the change is too slight to be reliable.
3. *The edge characteristics of blood spots* have absolutely no meaning or value unless the effect of the target surface is well known. This is especially true when attempts are made to estimate distance from the so-called "scallops" around the edge (Figures 8.3 through 8.6).
4. *The degree of spatter* of a single blood drop depends far more upon the smoothness of the target surface than the distance the drop falls. The coarser the surface the more likely the drop will be ruptured and spatter. A blotter, for example, will cause a drop to spatter to a considerable extent at a distance of 18 inches, whereas a drop falling over 100 feet will not spatter at all if it lands on glass or other smooth surfaces.
5. No conclusion as to the cause of a very small bloodstain should ever be drawn from a limited number of stains. Very fine specks of blood may result from an overcast or cast-off satellite from a larger drop or droplet. In the absence of the larger drop, however, when hundreds of drops smaller than 1/8 of an inch are present (often down to 1/1000 of an inch in diameter), it may be concluded that they were produced by an impact; the smaller the diameter of the drops is, the higher the velocity of the impact that produced them. The difference between medium-velocity impact, such as an ax or hammer blow, and high-velocity impact, such as a gunshot, is sufficient for differentiating the two, provided an adequate sample is observed by someone thoroughly familiar with blood stain pattern reconstruction.
6. *Directionality of a small bloodstain* is easily determined, provided the investigator recognizes the difference between an independent spatter and a castoff or satellite thrown from a larger drop. Small independent stains have a uniform taper resembling a teardrop and always point toward their direction of travel. Cast-off droplets produce a tadpole-like, long narrow stain with a well-defined "head." The sharper end of these stains always points back toward their origin. Because these satellite spatters travel only a very short distance, the larger drop can almost always be traced (Figure 8.7).
7. *The character of a bloodstain*, made by drops or smaller droplets or by larger quantities of blood up to several ounces, may reveal movement at the moment of initial staining or later if a body or other stained surface is moved from its original position.
8. Depending upon the target and impact angle, considerable back spatter may result from a wound. The range of back spatter is considerably less than that occurring

[4] Herbert L. MacDonell, Flight Characteristics and Stain Patterns of Human Blood, U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, PR71-4, November, 1971.

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Figure 8.1 Bloody shoe prints of the suspect's shoes found at the crime scene clearly show blood drops and spatters on top of the shoe prints. This evidence places the suspect at the scene during the incident rather than after, as he had contended. *(Fulton County Medical Examiner's Office, Atlanta, Georgia.)*

in the same direction of the projectile, however. This is especially true with exit wounds when expanding-type slugs are used.

9. Blood is a very uniform material from the standpoint of its aerodynamics. Its ability to reproduce specific patterns is not affected to any significant degree by age or gender. Likewise, because blood is shed from a body at constant temperature and is normally exposed to an external environment for such a very short time, atmospheric temperature, pressure, and humidity have no measurable effect on its behavior.

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Figure 8.2 A murder scene with a bloodstain pattern shows that the victim was dealt a blow at the top of the stairs and was struck an additional, fatal blow at the foot of the stairs. *(Royal Canadian Mounted Police, Forensic Laboratory Services.)*

In summary, bloodstain pattern evidence requires much experience and testing of the surface characteristics of the target to determine how blood falling on that surface will behave. Bloodstain pattern interpretation courses are available and it is highly recommended that such a course of study be taken prior to attempting this technique on actual casework. Training and experience will allow for the greatest amount of useful information to be derived from this technique. Crime scene reconstruction through the use of bloodstain pattern interpretation is a useful technique but only those who have the necessary amount of training should use it. The directionality of a bloodstain is a much easier area for interpretation. With these teardrop-shaped stains, the pointed end will always point toward the direction of travel (Figure 8.7).

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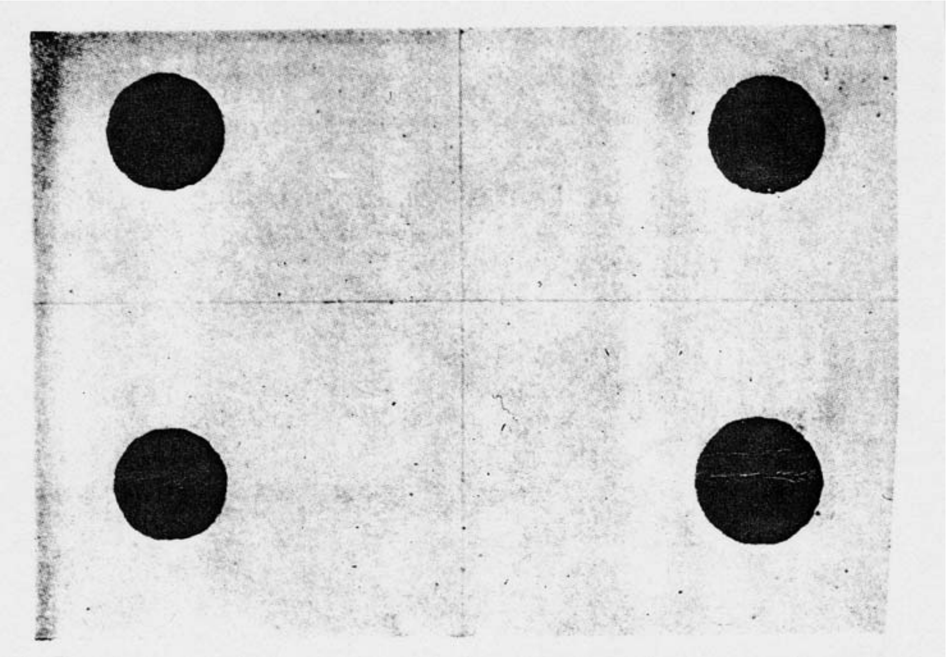

Figure 8.3 Drops of blood on a plain surface falling from a height of up to 20 inches.

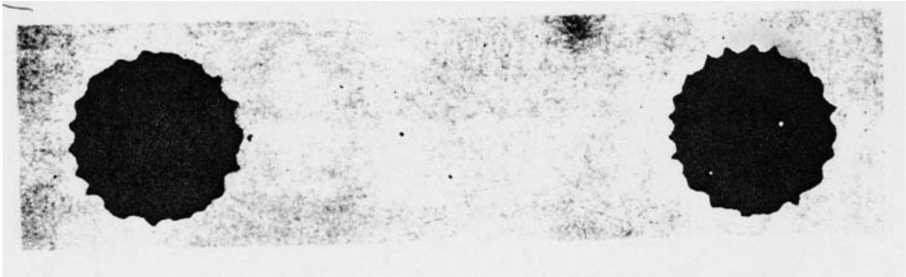

Figure 8.4 Drops of blood from a height of 20 to 40 inches. The scallops are large and sparse.

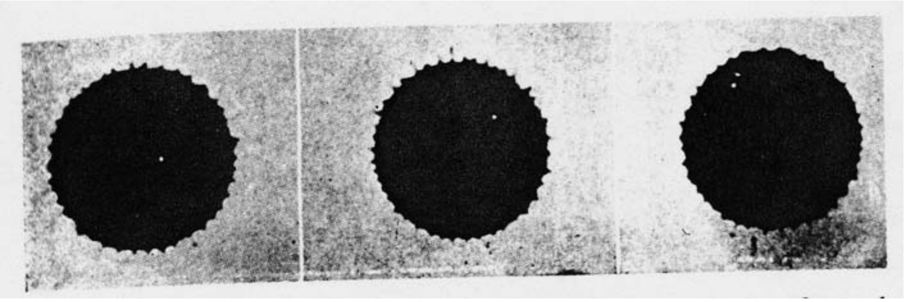

Figure 8.5 Drops of blood from a height of 40 to 60 inches. The scallops are fine and close.

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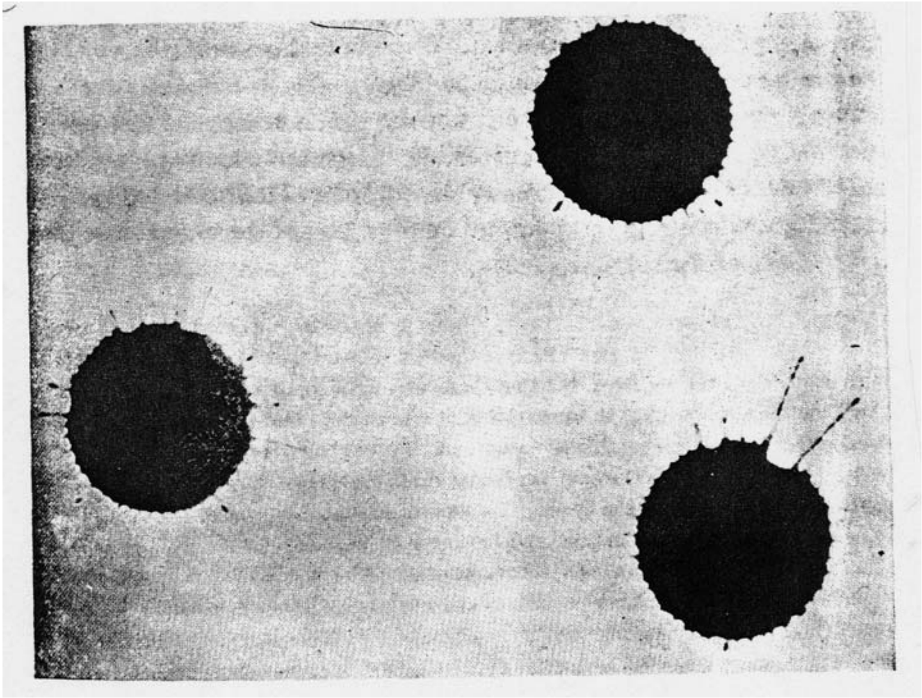

Figure 8.6 Drops of blood from 60 to 80 inches. The scallops are fine and close and spatter out in a sunray design.

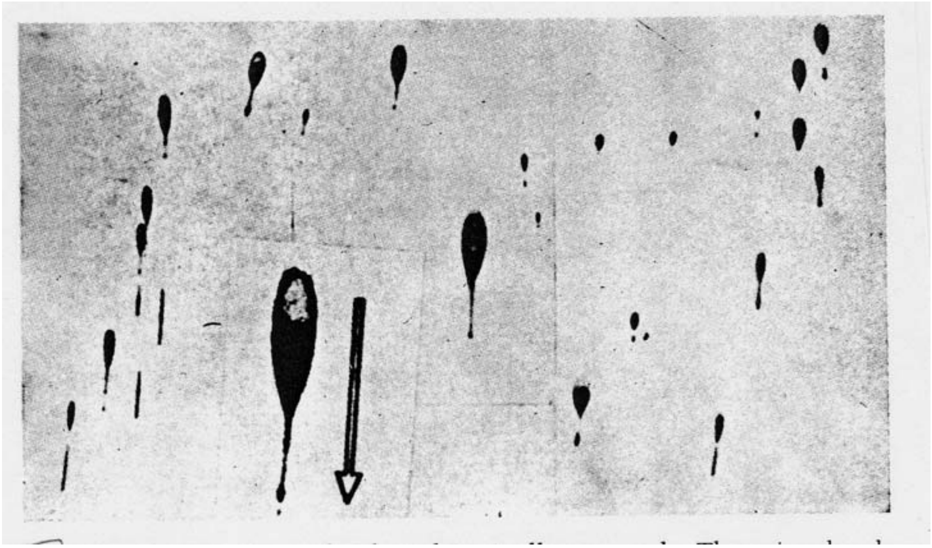

Figure 8.7 Bloodstain patterns that have hit a wall at an angle. The pointed ends indicate the direction of movement (see arrow).

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Presumptive Tests for Blood[5]

Scenes of violent crimes often contain minute quantities of blood that, because of their small size, may not be readily noticed. Presumptive blood tests (sometimes called catalytic tests) may be used to search for these small bloodstains. These chemical tests are also useful at scenes where the suspect cleaned up the area or to differentiate between blood and other stains (e.g., rust, chocolate milk, etc.).

Historically, several chemicals have been used as presumptive tests to determine the presence of blood: leucomalachite green, phenolphthalin,[6] ortho-tolidine, and tetramethylbenzidine. All are presumptive or screening tests. Another presumptive test, luminol, is described later.

Presumptive tests are color spot tests that depend on the properties of hemoglobin. They are extremely sensitive and can easily detect very small quantities of blood. The test results are easy to perform and lend themselves to use by crime scene technicians. Interpretation of test results is critical because other materials can give false-positive results. A positive result can result from the presence of human or animal blood and a variety of plant materials that contain the chemical peroxidase.

Chemical kits used for presumptive tests are available through law enforcement supply companies, or bulk chemicals may be purchased at considerable savings from chemical supply houses.

A word of warning! Some of the chemicals used to screen blood are carcinogenic or cancer causing. As in all chemical usage, care must be taken. If the chemical comes in contact with the skin, it should be thoroughly washed with soap and water. Wearing rubber gloves is suggested.

Of the foregoing tests, phenolphthalin and leucomalachite green are generally considered the most specific while ortho-tolidine and tetramethylbenzidine are the most sensitive. Generally, the phenolphthalin or K-M test is a good overall choice. The test may be conducted on filter paper or on cotton-tipped applicators. Performing the test directly on the evidence is not recommended.

The luminol test is easily used in the field and very useful for searching large areas for blood, particularly if the area has been cleaned up. A drawback of the test is that the room must be dark because blood reacts with luminol reagent by luminescing. The reagent is sprayed with an aerosol sprayer. The glow given off is very faint; therefore, the area must be almost completely dark in order to visualize the luminescence. The test works best on older stains. In some instances, outlines of shoes and even marks caused by mopping or wiping up an area can be clearly visualized by means of this test. Experience in interpreting this test is required. At times, pinpoint glowing is observed, which is not the result of bloodstains; with a positive test, whole areas are seen glowing.

Searching for Bloodstains

A dried, but relatively fresh bloodstain is generally reddish-brown in color and glossy in contrast to, for example, rust stains. In a very thin layer, the color may be grayish green.

[5] For an excellent review of presumptive tests, see Cox, M., A study of the sensitivity and specificity of four presumptive tests for blood, *J. Forensic Sci.*, 36(5), 1503–1511, 1991.
[6] The phenolphthalin test is also known as the Kastle–Meyer or "K–M" Test.

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The gloss slowly disappears under the action of sunlight and heat, wind, and weather or as the result of an attempt to wash it away; the color finally becomes gray. Bloodstains can assume other colors from red to brown or black, or they may appear green, blue, or grayish white. The color and the time required for the change depend on the underlying material: the change is quicker on metal surfaces and slower on textiles. With some types of cloth the blood soaks into the threads; with others it lies on the pile. The surface gloss is often less marked on fabric. Bloodstains on wallpaper may show surprising colors because of the blood's taking up color from the paper. Certain other stains, composed of pigment, rust, tobacco, snuff, urine, feces, coffee, and other substances, can easily be confused with bloodstains. In searching for bloodstains, marks should not be classified according to color and character because a stain that appears to deviate from the normal character of a bloodstain may be composed of blood, whereas one that resembles blood may be composed of some other substance.

When searching for stains it is convenient to allow the light from a flashlight to fall obliquely against the surface under examination. Sometimes a stain shows up better against a surface when it is illuminated with colored light. Red, green, and ordinary white light have been used successfully.

Occasionally, the assailant will clean up the scene. Furniture is straightened, damage is concealed, and blood is washed off — all for the purpose of concealing the crime, delaying its discovery, and/or destroying evidence. The search of the scene should therefore also be extended to places that are not in direct view. A criminal with bloody fingers may, for example, have opened a drawer, leafed through papers, grasped a doorknob, etc. Washbasins, garbage pails, and similar items should be given close attention. Drain traps should also be examined because blood may be in the trap if the criminal washed his hands there. Towels, draperies, and other fabrics that may have served to wipe off blood should also be examined. If a floor has been washed in order to remove bloodstains, blood may possibly be found in its cracks, in joints between tiles, under the edges of linoleum, and in similar places.

The search for blood on clothes must be carried out carefully and systematically. Even if blood has been washed off the more conspicuous parts, stains may still be found on the seams, on the lining, inside the sleeves, in pockets, and so forth. Stains that have been diffused by washing may be concentrated in the laboratory; in some cases, typing has been successful. Suspects may also have bloodstains not only on their clothes, but also on their body.

In the open air, the search for bloodstains is often more difficult. Rain, snow, sun, and wind may have obliterated the marks more or less completely. The blood mark may have changed its color in a very short time because of the character of the ground. If the ground gives an impression of dampness in certain areas, these parts should be given special attention, as should blades of grass, leaves, branches of trees, etc.

Objects on which the presence of bloodstains is suspected should be examined very carefully in cracks, joints, and seams because bloodstains can sometimes be found in such places even after the object has been washed or cleaned. It should also be remembered that it does not follow that blood must be found on a knife or similar object that has been used in a murder or assault. The edges of the wound may wipe the blood off the blade as it is drawn out.

If blood has run through bedclothes on a bed it is necessary to consider whether it has run through all the bedclothes or has remained in the mattress, for example. This is

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very important in estimating the total quantity of blood and sometimes in enabling the pathologist to decide on the time that has elapsed since death.

Description and Recording of Bloodstains

In the case of bloodstains, a description should be made of their form, color, size, position, direction of splash, estimated height of fall, and the like. The best way to preserve the appearance of bloodstains is through photography. Photographs depicting overall, medium-range, and close-up views should be made. A scale should be included for the close-up photographs.

Besides photography, a rough sketch is useful to show the general appearance of the stains as well as their relative position to other areas of the crime scene. The sketch should contain the location and direction of the stains, for example, a drop of blood located 25 inches from the floor and 16 inches east of the doorway on the north kitchen wall indicating a downward direction.

Collection and Preservation of Bloodstains

Of all the common types of evidence found at crime scenes, blood is perhaps the most fragile. The value of bloodstains for typing begins to diminish almost immediately. The stability and utility of bloodstains varies from several days to months depending on the environment. Naturally, proper preservation procedures improve the chances of determining blood types. It is a certainty that wet or damp bloodstains packaged in airtight containers, such as plastic bags, will be useless as evidence in a matter of days. Any type of preservation technique that hastens putrefaction should be avoided. Thus, storing bloodstains that are still damp in airtight containers or in warm environments will accelerate deterioration of the specimen. Conversely, an air-dried sample stored in a paper bag at room temperature, or better, under refrigeration, will retain its evidentiary usefulness for a significantly longer period of time.

Once blood evidence has been found it must be collected and preserved in a manner to achieve maximum benefit. All too often improper collection and preservation of this type of evidence make the crime laboratory's work difficult and sometimes impossible.

Preservation of blood and other biological evidence may require special handling in jurisdictions with case law dealing with preservation of such evidence. Biological evidence, i.e., blood, semen, saliva, and so forth, does deteriorate with time. Drying and freezing the specimens slows down this deterioration. Some courts have held that the police have an affirmative duty to preserve evidence for defendants that can prove their innocence. In those jurisdictions, it is essential that biological evidence be stored frozen. Failure to do this may result in the evidence being excluded and, in some instances, the entire case thrown out of court.

Even in those locales that do not have the legal requirement to store blood, semen and other biological evidence under freezer conditions, such a practice is recommended, simply because it extends the useful life of the material. Many laboratories operate under a high caseload and often it is not possible to examine the evidence immediately. Storing this

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evidence in a dry, frozen state will maintain its usefulness for many months and perhaps provide valuable information for the investigator.

Removal of Bloodstains

Blood may be present in a liquid, damp, or completely dry state. Depending on the circumstance, different procedures may be used. The easiest method of collection of wet blood is to place an absorbent piece of material into the still-liquid pool of blood. Materials such as filter paper, cotton-tipped applicators, and cotton gauze may be used. A good procedure is to use clean, white cotton fabric similar to that used in men's 100% cotton handkerchiefs. This material can be cut into 1/4-inch square pieces and used in the collection of wet and dried bloodstains.

The cotton fabric swatch is placed in the liquid blood and allowed to become saturated. The fabric is removed from the blood by means of forceps and placed in a test tube that has purposely been left unstoppered to allow the fabric to air-dry. The tube should be marked to clearly indicate where the specimen came from and who collected it. This is especially important when several blood samples are collected.[7]

If cotton swatches are not available for collecting wet blood, a sterile cotton gauze pad from an adhesive bandage or a Band Aid® can be used. The cotton gauze pad is placed into contact with the pool to become saturated with blood. The bandage can then be attached by means of the adhesive tape to a clean 3- × 5-inch index card. The card is appropriately marked with the necessary identifying information. Liquid blood collected in this manner can air-dry on the cotton bandage and remain useful as evidence for some time.

Most blood found at crime scenes is dried. Collection of dried blood specimens may be accomplished in a variety of different methods. If the blood is particularly crusty or flaky it can be removed by a razor blade, scalpel, or clean pocketknife and scraped onto a clean piece of paper. The paper is then folded in a way to minimize loss of the blood. The folded paper is marked and placed in an envelope and sealed. The envelope is used to protect against loss of the blood if the paper should unfold.

Blood present as dried smears or dried droplets does not lend itself to the scraping technique. It may be collected on a moist cotton swatch approximately 1/4-inch square. The swatch is moistened with distilled water and held in forceps. The damp cloth is swabbed over the area of interest with an effort to concentrate the blood onto the moistened cotton fabric. Generally, a dark, rust-colored stain soaked onto the cotton fabric indicates that an adequate sample has been collected. After the sample is collected, place the swatch into a clean, dry unstoppered test tube that has been marked. The unstoppered tube allows the stain to air dry.

Bloodstained Objects

Generally, it is best to submit the entire bloodstained object or item to the laboratory rather than remove the blood. The location of the object must be carefully noted and

[7] A simple practice is to label the item using your initials followed by a number, e.g., BF-1, BF-2, BF-3, etc. Field notes would indicate the location of each item.

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photographed. If blood on the object appears loose and likely to flake off, it should be collected and packaged separately before packaging the item of interest.

Packaging bloodstained items must be done in a way so as not to destroy the evidence. Packaging in airtight containers must be avoided. Bloodstained articles placed in sealed plastic bags or even tightly wrapped in paper will readily putrefy and render the blood evidence useless.

Items such as damp bloodstained clothing should, if possible, be allowed to air-dry. The drying should be done at room temperature away from direct sunlight. Items should then be packaged separately and loosely in wrapping paper or paper bags.

If wet or damp bloodstained items cannot be air-dried, they should be packaged separately in wrapping paper or paper bags. They should not be tightly rolled or bundled up because this accelerates putrefaction of the stains. Whether wet or dry, newspaper should not be used.[8]

When items of clothing are collected, a useful habit to develop is to initial the items as soon as the evidence is received. Develop a routine of always marking the item in the same location, such as on the inside collar of a shirt or the back inside waistband of trousers.

Often, it is not feasible to submit an entire large item of bloodstained evidence, for example, a bloodstained carpet or mattress, to the laboratory. There are two ways to collect blood in such instances. The first is to follow the already outlined procedure of using the 1/4-inch moistened cotton swatch. The second is simply to cut out a portion of the item containing the bloodstain. The cutting is then placed in an appropriate package and marked.

When cutting out a specimen of carpet or mattress for blood typing, an unstained area next to the stain should be collected as well. This is a *control sample* and is necessary to determine if anything normally in the material may cause a false-positive test.

Control samples must also be taken when swabbing dried stains with the moistened 1/4-inch square cotton fabric. This is accomplished by swabbing an unstained area adjacent to the stained area with a clean piece of cotton cloth.

Blood Typing

Blood typing evidence is capable of eliminating suspects as well as incriminating them. However, to give meaning to blood collected at a crime scene, blood samples from victims and suspects must be routinely submitted to the crime laboratory along with the evidence.

Collection of Known Specimens

It is important to collect known, whole blood specimens in an appropriate way. Only a physician, nurse, or medical technologist may draw blood. It is especially important to use the proper collection container. Most hospitals are accustomed to collecting blood for toxicology examinations such as blood alcohol and may not be aware of the best type of tube to be used for blood typing. Do not use just any tube. If uncertain about the correct

[8] If the items are blood soaked and it is not possible to dry the evidence, it is permissible to use large plastic bags to transport the evidence to the laboratory. However, the evidence should be removed from the plastic as soon as possible to air-dry. Wet, bloodstained evidence should be air-dried first before mailing.

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tube, contact the crime laboratory. Beyond determining that a dried sample of material is in fact blood, a crime laboratory can determine several other useful pieces of information; species origin and blood type are the most important. Buccal swabs or swabs from the inside cheek are an alternative to blood samples. Commercial kits are available for this purpose.[9]

Species origin is simply a test to determine the species of animal from which a blood sample came. The amount of blood required for this test is very small; however, it is important to have a control specimen to rule out the possibility of false-positive tests.

Approximately two dozen different animal antisera are commercially available for use in the species origin test. For criminal cases, the most often used antisera are human and domestic animal antisera such as dog, cat, cow, horse, deer, and so on. Differentiating closely related species of animals may sometimes be difficult. Species determination is also useful in animal poaching cases.

Forensic DNA Typing

Most crime laboratories have abandoned ABO typing and the procedure known as protein electrophoresis in favor of forensic DNA typing. DNA typing refers to several procedures in use by forensic science laboratories.

DNA typing is based on our genetic makeup. Anyone who has attended a sporting event or been in a large crowd of people recognizes the obvious: people look different. Differences are manifested by gender, race, stature, hair color, eye color, and shape of facial features, to name a few of the common features. The fact is that people can easily recognize others through some subjective mental process.

We can also recognize family traits among brothers and sisters, parents and children and sometimes even more distant familial relationships. How often have people commented that a son looks just like his father or mother or "I can see grandmother's eyes in yours"? These family characteristics can be seen over and over in family lineage.

An individual's physical appearance and family traits are a manifestation of the biochemical blueprint and building blocks that make people unique. The notion of differences and similarities in individuals has its scientific basis in the study of genetics. Genetics' roots go back to the mid-19th century when Gregor Mendel suggested that genes controlled factors influencing heredity. During the next hundred years, major strides were made in the study of genetics, genes and the more fundamental units, chromosomes, and the basic unit of the chromosome, DNA.

DNA or deoxyribonucleic acid is the biochemical key to differentiating uniqueness among individuals (with the exception of identical twins). It has been called the chemical messenger in that it conveys genetic information that is the basis of the way individual living things take shape, grow, and reproduce.

Pictorially, the DNA molecule resembles a twisted ladder or double helix. The steps within the ladder consist of four chemical subunits or bases: guanine (G), adenine (A), thymine (T) and cytosine (C). The bases pair in predictable ways — A always with T and G always with C — and form the steps or rungs of the double-stranded DNA helix. The

[9] See, for example, Bode Technology Group, Buccal DNA Collector at http://www.bodetech.com/services/buccal_overview.html. Investigators should consult with their forensic science laboratories to determine which known or standard sample collection method is acceptable to the crime lab.

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Figure 8.8 (A color version of this figure follows page 256.) Even a small quantity of blood, such as in this case, is sufficient for DNA typing. *(Los Angeles County Sheriff's Department.)*

combinations of the A-T and G-C are referred to as base pairs. Over 3 billion base pairs are in human DNA; however, only small portions of these base pairs determine unique traits between persons and are of forensic interest.

DNA is folded into microscopic bundles called chromosomes and exists in all cells that contain nuclei. DNA is not present in red blood cells because these cells have no nuclei; other cells present in blood contain DNA, however. DNA is present in blood, seminal fluid, tissues, bone marrow, hair roots, saliva, urine, and tooth pulp. Each of these samples has the potential to yield DNA typing results.

Recent advances in biology have permitted scientists to unravel the DNA code and examine pieces of DNA to look for similarities and differences between individuals. For forensic DNA purposes, two procedures are in use: RFLP (restriction fragment length polymorphism) and PCR (polymerase chain reaction). Another PCR-based methodology is known as STR (short tandem repeats). These technologies play an important role in forensic DNA databases.

RFLP-Based Technology

This technology is based on the fact that certain regions of DNA consist of repeated sequences of units that are referred to as variable numbers of tandem repeats or VNTRs. These are regions of DNA of no known function. The exact number of these consecutively repeated sequences varies from individual to individual; therefore, the length of the VNTR region varies. It is for this reason that VNTRs can be used as markers for human identification.

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A procedure known as electrophoresis separates VNTRs of different lengths after they are placed in a gel and exposed to an electric field. This separation is possible because, in general, the smaller fragments move faster through the gel than the larger ones.

The procedure works as follows: a bloodstain, semen stain, saliva stain, or some other biological evidence sample is chemically treated in order to purify the DNA (the particular chemicals used depend on the tissue sample). A *yield gel* is run to test the quality of the DNA and the amount recovered. Sometimes this gel will indicate too little DNA to proceed or that the DNA is degraded. (VNTRs break down into small fragments as they age or if they are exposed to certain environmental conditions.)

If the DNA quality is good, the analysis continues with the addition of restriction enzymes to the DNA sample. Although there are a number of different types of restriction enzymes, each one will recognize a particular sequence of the DNA and will cut in this region. As a result, millions of DNA fragments of different sizes form; these are then separated, based on the size differences, by electrophoresis. The separated DNA fragments are double stranded at this point and are treated with chemicals to form single-stranded bands. The bands are then transferred to membranes (through a process called Southern blotting) because gels are not easy to work with (they are fragile, they dry up, stick to surfaces, etc.).

Single-stranded DNA probes are then added to the membrane. The probes are manufactured so that they have complementary sequences to target VNTRs that were separated in the gel and therefore transferred to the membrane. The probes will bind to complementary VNTRs and any that remain unbound are washed off. Up to this point, the bands are not visible to the analyst. The probes have a radioactive label attached and as the membrane is brought into contact with x-ray film, the probe exposes the film, which indicates the location of the VNTRs. The x-ray film is then developed and referred to as an autoradiograph or autorad. Many forensic labs now use chemiluminescent probes instead of radioactive probes because these allow quicker typing results.

PCR-Based Technology

Polymerase chain reaction (PCR) is a technology that copies short segments of DNA millions of times in a process that resembles the way in which DNA duplicates itself naturally in the body. (Some have described this process as the equivalent of a biological Xerox® machine.) A refinement of PCR technology is a process called short tandem repeats (STR) that combines PCR with RFLP and is used on larger segments of DNA.

PCR is a powerful technology because it can be applied to any tissue specimen, no matter how small, degraded or old, and produces billions of copies within a few hours (e.g., a single hair with its root, dried saliva on the back of a letter or postage stamp, dandruff, etc.). The PCR process consists of initially separating the DNA double helix into two strands by heating the sample. A PCR reaction mixture is then added. It consists of a pair of DNA primers (short segments of DNA that are added to indicate the target segment of DNA to be copied), DNA polymerase (an enzyme that catalyzes the reaction) and the four nucleotide bases A, C, T, and G. This mixture contains all the ingredients necessary to copy both of the original DNA strands that were separated. The procedure is performed in an instrument called a thermocycler and typically repeated for about 30 cycles.

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Figure 8.9 (A color version of this figure follows page 256.) A criminalist working on sexual assault evidence wears personal protective equipment (PPE) including a lab coat and gloves. The purpose of the face mask is to minimize evidence contamination. *(Los Angeles County Sheriff's Department.)*

Once the amount of DNA is amplified by PCR methods, the analysis can proceed in a number of different ways. In addition to the conventional dot blot analysis, probes have been developed that can be used in reverse dot blot typing. This typing method and the conventional method are based on a variation in the DNA base sequence rather than on the length variations that distinguish the VNTRs separated by RFLP.

Mitochondrial DNA

Yet another type of DNA typing is called mitochondrial DNA (mt-DNA). Mitochondria are found in the cytoplasm of most cells. They play an essential part in generating the energy necessary for cell function. Mitochondrial DNA is contained within each mitochondrion. This distinct source of DNA differs from the DNA found in the nucleus of cells (nuclear DNA) in a number of respects:

- Mitochondrial DNA is a much smaller molecule (it is circular as opposed to helical).
- Mitochondrial DNA is only inherited maternally.

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- Mitochondrial DNA is present within a cell in multiple copies because there are many mitochondria located in a particular cell and many copies of DNA molecules within each mitochondrion. The actual copy number varies with cell type, depending on the energy requirements of the cell. For example, 20 to 25% of a liver cell is composed of mitochondria whereas 50% of the volume of a cardiac cell comprises mitochondria. Nuclear DNA is only present in two copies per cell (one copy in the case of an egg or sperm cell).

Two approaches have been used to analyze mitochondrial DNA. Both are based on typing the control region (also called the D-loop region) because it is in this segment of mitochondrial DNA that most of the variation from one person to another is found. The first method is direct DNA sequencing analysis in which the sample is initially copied using PCR and the products of this amplification are read by a DNA sequencer. This technique is expensive and labor intensive. The second method is conventional dot blot analysis. In this application, each PCR-amplified DNA molecule is separated into single strands and fixed onto membranes in a process known as dot blotting. A specific probe is then added to the membrane and hybridization occurs if the DNA sequence is complementary to the probe. The results are visualized using audioradiography.

Mitochondrial DNA typing has a number of applications in criminal investigations. It can be used as a rapid, cost-effective investigative tool for the identification of missing persons because it is possible to use the mother, sibling or any other maternal relative as a reference source since they possess an identical mitochondrial DNA type. In the case of nuclear DNA, this is only possible if a person has an identical twin or if multiple nuclear genetic markers are typed from the parents of a missing person. In certain cases, DNA is degraded due to environmental insults, aging, or some other factor limiting the quantity of DNA extracted. Thus, it is incapable of producing a typing result with RFLP-based technology. The high copy number of mitochondrial DNA means a higher likelihood of survival of intact sequences that can be applied to PCR-based technology. Furthermore, the high copy number of mitochondrial DNA means a greater chance of success with samples that have little or no nuclear DNA to begin with, e.g., shed hairs.

Another useful application of mitochondrial DNA is in detecting stain mixtures. This relates to the fact that it is inherited only from the mother and therefore a less complicated analysis results when compared to nuclear DNA markers. In other words, if more than one mitochondrial DNA type is detected, it is likely that a mixture is present. However, because nuclear DNA is inherited from both parents and an individual can be homozygous or heterozygous, interpreting a mixed stain is more problematic.

CODIS

CODIS is the acronym for the *Combined DNA Index System*, an FBI-sponsored initiative similar in concept to the automated fingerprint identification system, AFIS. CODIS consists of a felon database made up of the DNA samples collected from persons convicted of certain specified crimes and evidence samples from crimes such as assaults, sexual assaults, and homicides. Each state maintains its own database connected to forensic labs with appropriate DNA capability. The FBI is working to link together the entire system in a network; this will enable DNA searches across the entire country.

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Prior to CODIS, forensic scientists could manually compare DNA and conventional serology results to determine if there was a match. The national DNA database has resulted in an increasing number of "cold hits," i.e., matches of unknown suspects to DNA felon databases.

A key element to utilizing CODIS fully is to make certain that as many offenders as possible are entered into the database. Although most offenders sentenced to state prison have their DNA entered into the felon database, persons sentenced to county jail or placed on probation are not routinely sampled. It is recommended that investigators and forensic scientists be sure that such samples are collected.

CODIS has three files of DNA records:

- **Population File.** The population file consists of anonymous DNA profiles used to assist in the statistical interpretation of DNA profiles.
- **Forensic Index.** This file contains DNA profiles generated from crime evidence, as well as forensic DNA results from unknown subject offenders.
- **Convicted Offender Index**. Most states now have mandated that certain convicted offenders provide blood samples for DNA typing. DNA results are stored in each state's DNA offender index.

The initial CODIS DNA database used the RFLP technology. Although this technology yields very high discrimination between subjects and evidence samples, it is a very labor-intensive procedure that may take weeks to achieve test results. Because of this limitation, a changeover to a PCR-based system, known as STR (short tandem repeats), is underway. STR provides the best of both systems: it can be automated to achieve high throughput of case work while providing results that can prove to a high probability that a DNA specimen came from a single person.

Forensic DNA and Unsolved Cases

The use of DNA typing in crime laboratories has changed the way crime laboratories prioritize their casework, including nonsuspect rape cases. Prior to DNA typing, most laboratories did not perform blood typing on evidence in sexual assault cases in which there was no known suspect. The reasoning was simple: typing results could not be compared with a suspect; because resources are limited, such cases were not typed. The result was that nonsuspect rape cases were not examined.

Forensic DNA capability changes this policy. DNA data banking has the potential to identify unknown suspects based on their DNA type. CODIS make this all possible. Serial crimes such as rapes and murders will have a better likelihood of being solved because DNA typing results can be compared with DNA typing records collected from convicted violent felons. However, two things must happen: the convicted felon's specimen must be collected and typed and the laboratory must routinely examine its nonsuspect sexual assault cases.

SWGDAM

The Scientific Working Group on DNA Analysis Methods, SWGDAM (formerly TWGDAM, the Technical Working Group for DNA Analysis Methods) comprises a group of forensic

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DNA analysts from local, state, and federal laboratories throughout the U.S who have developed guidelines on quality assurance (QA) and quality control (QC). Quality control pertains to DNA testing standards implemented in a particular laboratory; quality assurance concerns monitoring laboratory operations. One example of quality assurance is proficiency testing, which can be either open or blind. In the former, the analyst is aware that the test is being conducted, whereas in the latter, the sample is submitted for examination under the guise of case samples. Accreditation agencies, which assess sources of error and the corrective measures taken by the laboratory, monitor the results of these tests. The tests may be repeated several times a year to assess these corrective measures.

DNA Cases

Case 1. Two women were raped in separate attacks. A suspect was arrested and identified by both victims. Meanwhile, two more women were raped under similar circumstances. A second suspect was arrested for those rapes. DNA typing was performed on semen from the victims' vaginal samples from the second set of rapes and compared to the second suspect. The DNA testing identified him. Because of the similarity of circumstances, the vaginal samples from the first two rapes were also tested and compared to both suspects. The first suspect who had been identified by both victims in court and held to answer was excluded, while the second suspect was identified in all four rapes.

Case 2. A permanently comatose teenage female was discovered to be pregnant. A juvenile friend of the victim's brother was the suspect. The fetus was aborted and submitted along with blood from the victim and the suspect for paternity testing with DNA. Blood samples from the victim's father and brother were also submitted for elimination. The juvenile suspect was excluded from having fathered the fetus. Unexpectedly, the brother was identified as the father.

Case 3. Three males allegedly raped two women. No semen was found in the vaginal samples; however, three used condoms were recovered from a trash can at the scene. Three suspects were arrested and identified by the victims as having participated in the rapes. One of the suspects was adamant that, although he was there, he did not participate in the rape. DNA testing was performed on the semen found inside each of the three condoms using RFLP testing. The exterior surfaces of the condoms were tested for the victims' DNA by PCR methods because of the small quantity of DNA found in the few vaginal cells remaining on the external surfaces of the condoms. It was determined that one of the suspects had raped one of the victims and a second suspect had raped both of the victims. Contrary to the victims' statements, the suspect who was adamant about not participating in the rapes did not contribute the semen found in any of the condoms.

Case 4. An adult female was found murdered and left in a position suggesting a sexual assault. Three suspects were generated by the investigation, with no investigative means to determine the true assailant from among them. Fingernail samples collected by the coroner's office contained a trace quantity of blood. PCR typing showed the blood was not the victim's. The results were compared to blood

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Figure 8.10 (A color version of this figure follows page 256.) The use of fluorescence is a rapid, convenient way to screen items and scenes for the presence of semen stains that can conclusively identify the donor. The inside surface of a blouse (A) shows no obvious stains, but the same surface, illuminated with an alternate light source, viewed through a filter dramatically shows the location of semen stains (B). *(South Australia State Forensic Science Laboratory, Adelaide, South Australia.)*

samples collected from the three suspects. One was included and the others were eliminated. No other methods available could have yielded a result on such a trace quantity of blood evidence. A charge of murder with special circumstances was filed against the suspect.

Case 5. Police conducting surveillance on an unrelated case discovered decomposing parts of a dismembered human body. The remains included the victim's head. A suspect was developed and blood drops were recovered in a search of his residence. The dismembered remains were too decomposed to provide a reference for genetic typing using conventional methods. Hair was removed from the victim's head and provided sufficient DNA for comparison to the blood drops recovered from the suspect's residence. The blood drops matched the victim and murder charges were filed.

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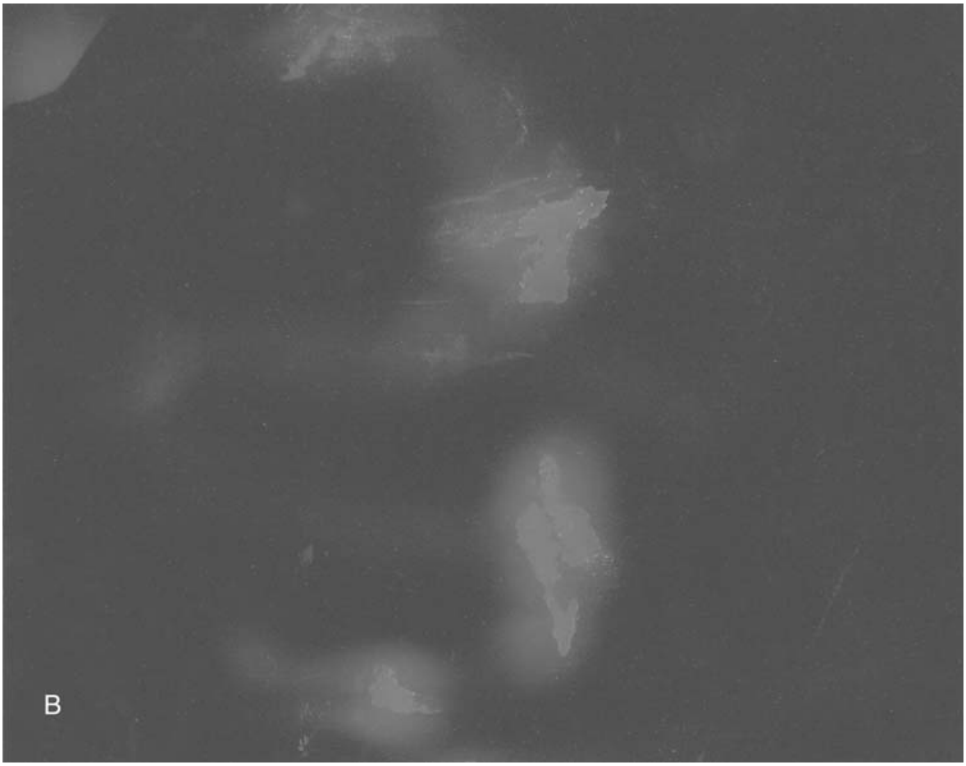

Figure 8.10 (continued)

Case 6. An executive in a major southern California business firm received threat letters. A suspect was developed who was an employee of the firm and had had an affair with the executive's wife. However, evidence was insufficient for an arrest or a search warrant. Subsequently, the chief of the investigating agency received a mailed bomb and a threat letter. The saliva residues on the threat letter envelopes sent to the executive and the Chief of Police were subjected to DNA typing using PCR testing. The results were also compared to saliva residue from love letters sent by the suspect to the executive's wife during their affair. The DNA types matched. This provided sufficient evidence for a search warrant for a sample of the suspect's blood. The blood sample also matched the saliva residues on the letters and the suspect was charged with attempted murder. The case was adjudicated by a plea bargain because of the strength of the identification of the suspect using DNA typing.

The Future

Forensic biology is among the fastest evolving technologies used in crime laboratories today. The revolution in the biotechnology industry makes it a near certainty that new DNA applications for forensic science will continue to develop for the foreseeable future.

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9 Impression Evidence

Case[1]

Charlie Richardson was a 30-year-old student completing his final year in medical school and preparing to intern. The victim, Maria Richardson, was the defendant's wife of several years. The defendant and Maria had a marital relationship that appeared normal to those who knew them. On the morning of December 30, 1988, the defendant drove Maria to her workplace, a laboratory located in El Cajon, California. While they were alone at the laboratory, an argument ensued and Charlie strangled Maria with a ligature. After killing Maria, he scattered and misplaced laboratory specimens and the contents of Maria's purse to make it appear that a burglar had committed the murder. Charlie then drove from the laboratory to the University of California, San Diego, medical school library to study for an upcoming exam.

Later in the morning, one of Maria's co-workers found her dead in the laboratory (Figure 9.1). The police arrived and began an investigation. Meanwhile, the defendant purchased items at several locations in the San Diego area, including roses for his wife. At noon, he returned to the laboratory under the pretense of having lunch with Maria. He wondered why he was not allowed to see his wife and why detectives were around the lab. Charlie was told of Maria's death and was then asked for background information about her. Charlie related his actions of the morning, explained how he left his wife at work, and then went to the library to study. He told investigators that he planned to meet Maria for lunch and produced time-stamped receipts from various locations.

The victim had ligature marks around her neck and chin (Figure 9.2). Several items that could have been used as the ligature were collected, including a long telephone cord attached to a wall phone. During the investigation, a small crescent-shaped abrasion was noted on the edge of Charlie's right pinky finger (Figure 9.3). Charlie, now a suspect, was read his *Miranda* rights. He explained the abrasion as a burn received while he was cooking; however, he was unable to explain a very small, less visible matching abrasion along the edge of his left pinky finger. Charlie

[1] This case was submitted by Norman D. Sperber, DDS, San Diego, California, and Detective Mike Howard, El Cajon Police Department, El Cajon, California.

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Figure 9.1 The victim found at the scene of her murder. Note the proximity of the telephone cord to her head. *(Norman D. Sperber, DDS, San Diego, California, and El Cajon Police Department, El Cajon, California.)*

Richardson was arrested for the murder of his wife Maria. Dr. Norman D. "Skip" Sperber, a forensic odontologist called into the investigation, made castings and took photographs of the suspect's fingers and of the ligature marks on the victim's neck (Figure 9.4 and Figure 9.5). The castings and photographs were compared with the wall telephone cord from the scene. In this case, the cord became critical evidence (Figure 9.6A, B, C). A search of the suspect's home yielded evidence of disharmony in the marriage; investigators also found writings by Maria in which she said she was afraid of Charlie.

Although the defense tried to suppress the evidence in pretrial motions, it was admitted in a jury trial. After considering all factors in the case, including the damaging evidence to be presented by Dr. Sperber, the defense offered to plead to a charge of involuntary manslaughter on condition that Charlie take the stand and tell the jury what had actually happened. The defendant took the witness stand and told how he strangled Maria with the telephone cord during the course of a heated argument.

Minute imperfections on a large variety of objects such as tools, footwear, tires, and so on produce markings in their normal (and sometimes unusual) usage. These markings are often characteristic of the type of tool or object used. In many instances, very small and sometimes microscopically unique markings are left that can be traced directly to the object or instrument in question.

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Figure 9.2 (A) The wall telephone and cord used to strangle Maria; (B) a close-up of the ligature marks on the victim's neck; (C) marks presumably made from the telephone cord on the victim's chin. *(Norman D. Sperber, DDS, San Diego, California, and El Cajon Police Department, El Cajon, California.)*

Such marks caused by a tool are of two general types: compression marks and scraping marks. *Compression marks* are those left when an instrument is in some way pushed or forced into a material capable of picking up an impression of the tool. Examples include shoe impressions, tire impressions, bite mark impressions, fabric impressions, the mark left by a hammer hitting a piece of wood, the mark of a screwdriver used to jimmy a window, breech mark impressions on shell casings, typewriter marks, etc. *Scraping or striated marks* are produced by a combination of pressure and sliding contact by the tool and result in microscopic striations imparted to the surface onto which the tool was worked. Examples of scraping marks are those found on fired bullets, left by a cutting tool such as a bolt cutter, from a wrench used on a doorknob, from an ax used to cut wood, from a screwdriver blade dragged over a surface, and teeth marks used to bite through a

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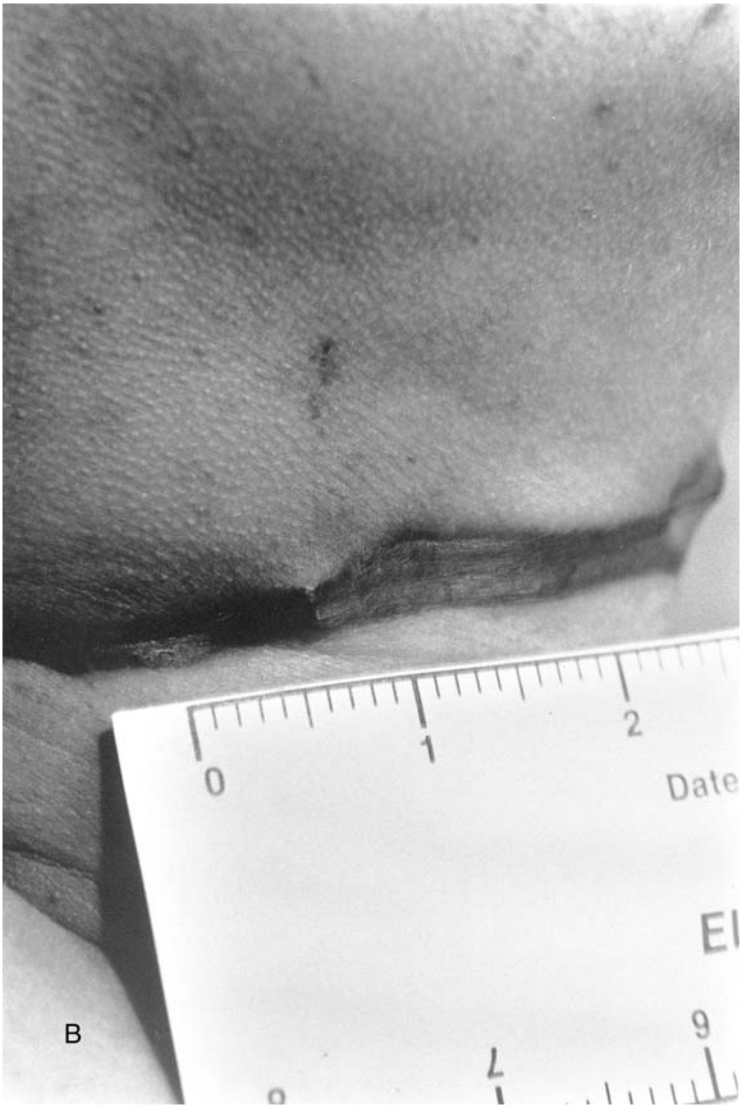

Figure 9.2 (continued)

soft material capable of picking up an impression. In order for compression or scraping marks to be observed, the tool must be made of a harder material than the object on which it is used.

The random nature and microscopic imperfections found on tools are a result of their manufacture and usage. Casting, grinding, and polishing metal instruments, as well as using them, result in small but observable differences from one tool to the next. Such differences have even been demonstrated in consecutively manufactured items.

Comparative examination is the method by which impression-type evidence is studied. The marks left at the crime scene (or castings of the mark) are compared with test markings made by the tool or object in question. Through careful and often tedious examination of the known and questioned evidence, a determination can be made as to whether or not a particular item was responsible for a specific mark.

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Figure 9.2 (continued)

Footprints

Footprints[2] are a common type of impression evidence found at or near crime scenes. In favorable situations such evidence may conclusively demonstrate that the suspect was at the scene of the crime. A detailed examination of footprints is tedious and time-consuming work, and as a result may be overlooked by the investigator. Although this discussion concerns footwear impressions, the investigator should not overlook soil evidence that might later be discovered on the suspect's shoes.

[2] The reader is referred to an excellent book on the subject, *Footwear Impression Evidence,* 2nd edition, by William J. Bodziak, CRC Press, Boca Raton, Florida, 1999.

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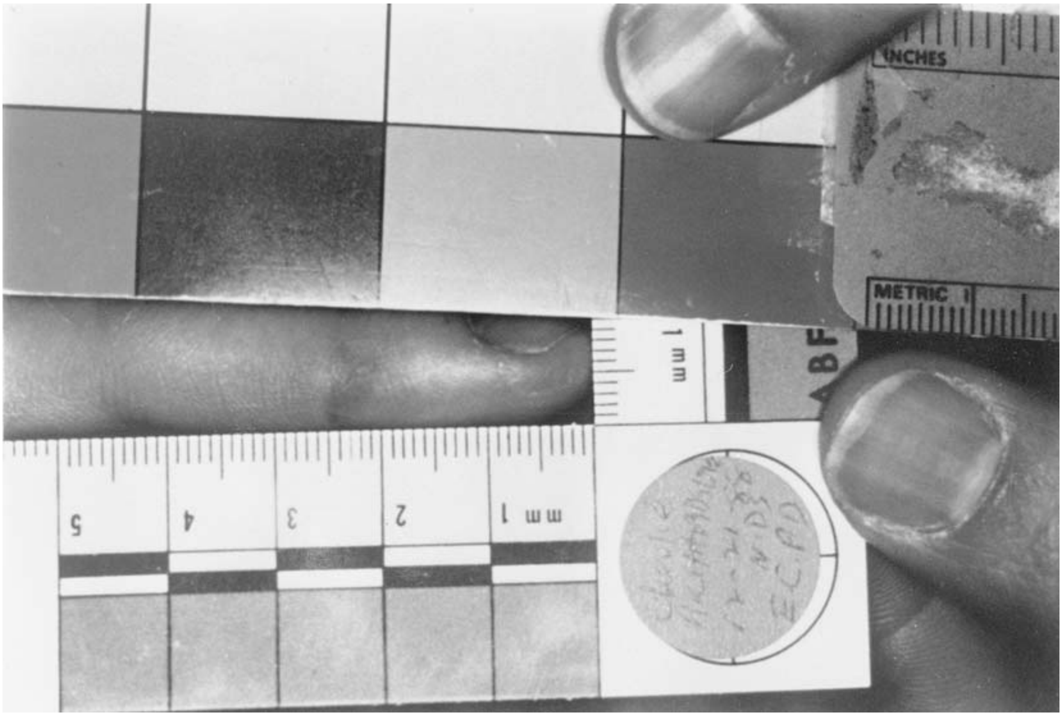

Figure 9.3 The abrasion on Charlie Richardson's right pinky finger, which the defendant explained was due to a burn received while he was cooking. He was unable to explain another less visible one on his left pinky finger. *(Norman D. Sperber, DDS, San Diego, California, and El Cajon Police Department, El Cajon, California.)*

When a cast is made of a footprint in soft ground, one would expect to obtain a faithful reproduction of the heel and sole of the shoe that made the print. As a rule, however, the result of casting is actually quite different — the cast has an arched form. The back of the heel and the point of the toe are considerably lower than the other parts of the cast because, in normal walking, the back of the heel is placed on the ground first. After that, each part of the heel and sole is pressed down on the ground in succession until the foot is lifted, with a final strong pressure of the point of the toe against the earth. The pressure that regulates the depth of the impression is the greatest at the back of the heel and at the point of the toe. When running, the footprints are less distinct, partly owing to slipping of the foot and partly to sand and earth thrown into the print. The form of the print depends on the individual's style of running; many people run on their toes, others set both heel and toe hard in the ground, and others set the whole foot down in the earth at once. In deciding whether an individual walked or ran the length of the step is the only certain guide.

The Value of Footprints

Individual footprints are generally preserved only if they contain details of value for identification. The most valuable details are signs of wear, characteristic fittings or marks of fittings that have come off, injuries, marks of nails and pegs, especially when these are irregularly placed, and repair marks. If they are particularly characteristic or occur in sufficient numbers, such details may form decisive evidence. In the interest of thoroughness,

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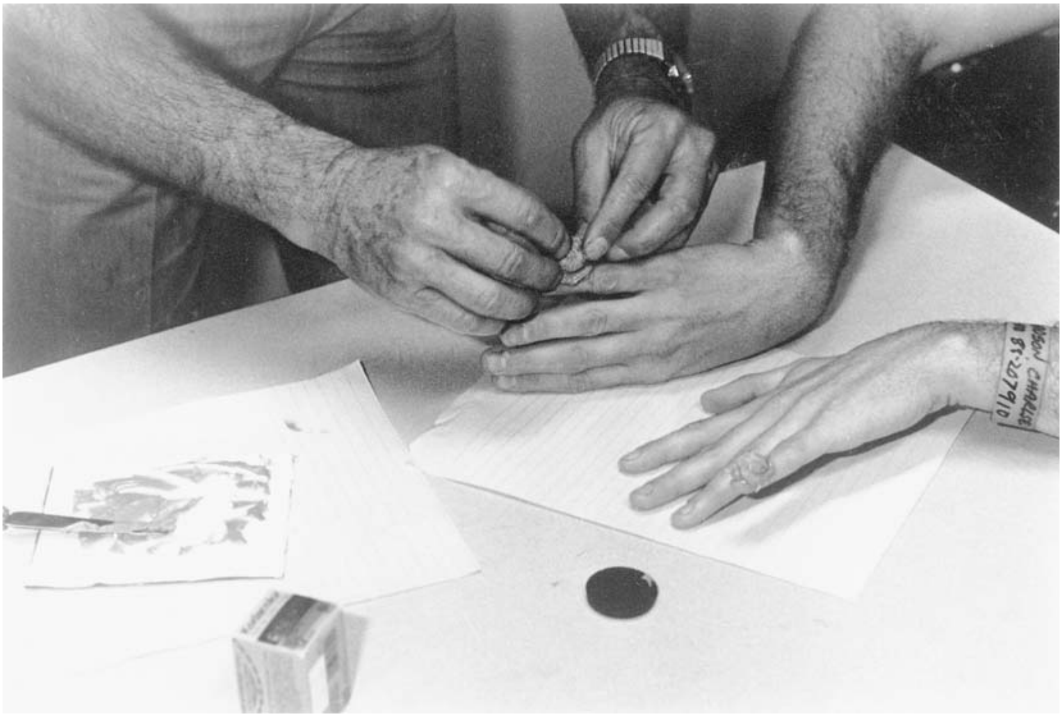

Figure 9.4 Dr. Norman Sperber making castings of the defendant's left and right little fingers. *(Norman D. Sperber, DDS, San Diego, California, and El Cajon Police Department, El Cajon, California.)*

footprints should be preserved even if they do not show any details. Although the size and shape of the shoe or a pattern in the heel or sole is of lesser evidential value, a representative print should nonetheless be preserved for its value as an investigative lead.

If footprints are found in snow that has a frozen crust, it is a waste of time to attempt to take a cast of them. When the foot breaks through the hard surface of the snow, the surface snow goes with it and forms a hard bottom to the mark. The coarse grains of ice in the surface layer do not reproduce any details of the shoe — not even such large defects as a hole through the sole — and it is not possible to obtain any useful information of the size by measuring the footprint because the hard snow is broken and pressed down at points considerably outside the outer contour of the shoe.

A footwear print may be a *foot impression* or a *footprint (dust print)*. *Foot impressions* occur when the foot treads in some moldable material such as earth, sand, clay, snow, etc. *Footprints* are formed on a hard base when the foot or the sole and heel of a shoe are contaminated with some foreign matter such as road dirt, dust, flour, blood, or moisture. Footprints may also be latent when naked or stocking-covered feet on a smooth surface have formed them.

Footwear impression evidence and information from the gait pattern may indicate that the subject was walking or running, had sustained an injury or walked with a limp, was possibly intoxicated, had a tendency to walk toe-in or toe-out, or was carrying a heavy object.

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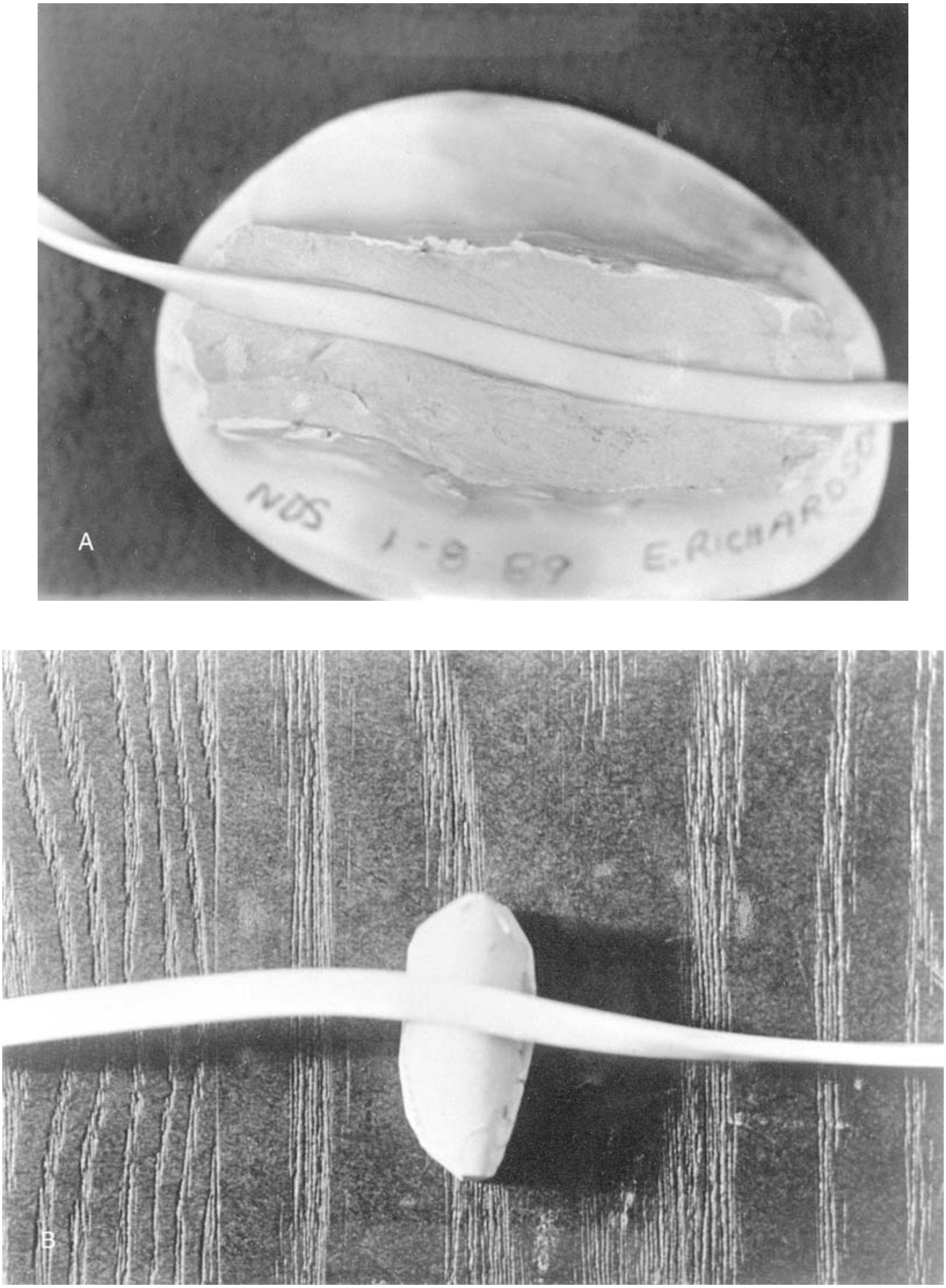

Figure 9.5 (A) The telephone cord fitted into a casting of the ligature mark on the victim's neck; (B) the telephone cord fitted onto a casting of one of the defendant's pinkies. *(Norman D. Sperber, DDS, San Diego, California, and El Cajon Police Department, El Cajon, California.)*

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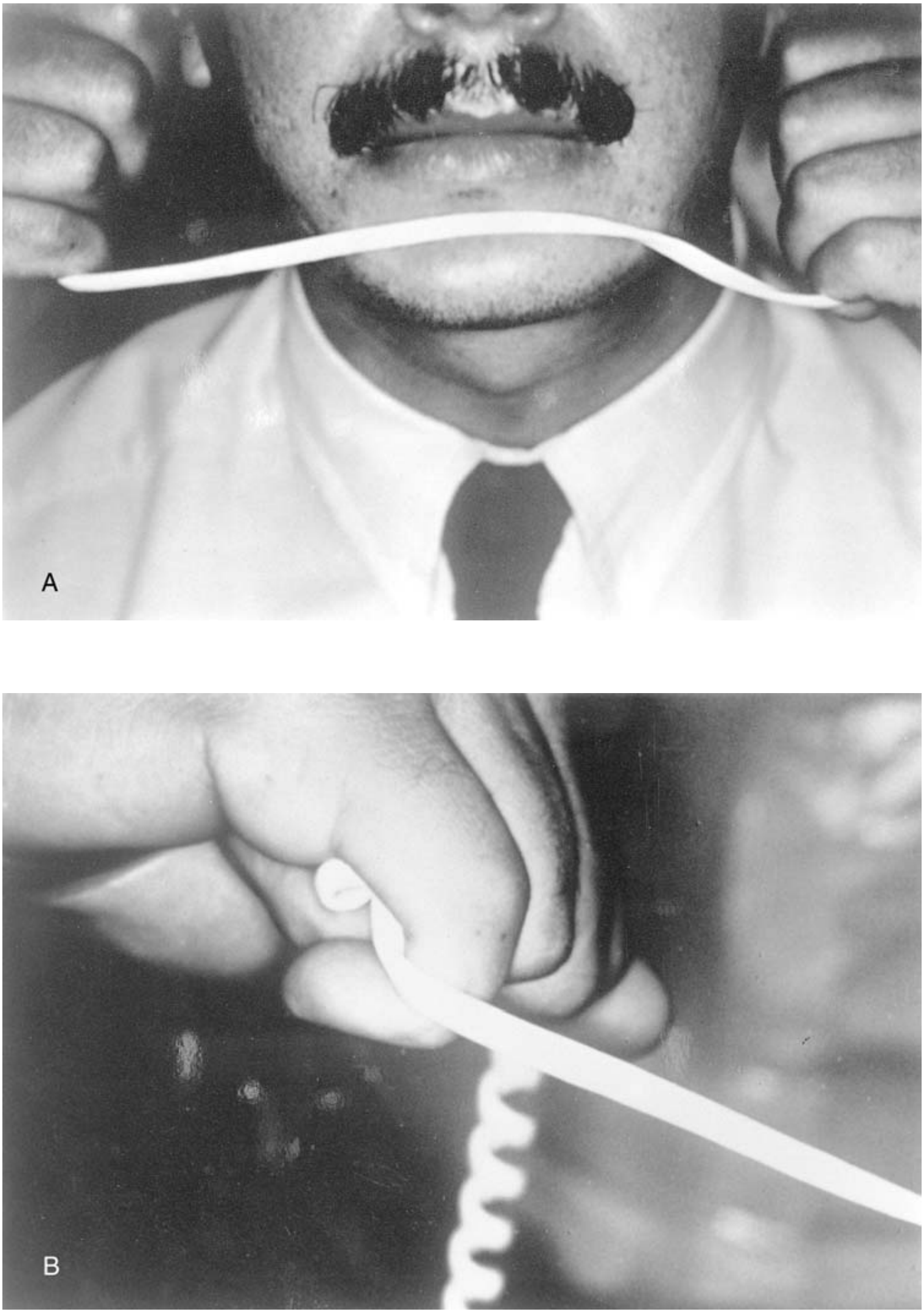

Figure 9.6 Two illustrations (A and B) of how the markings on the defendant's pinkies and on the victim's chin might have occurred; a close-up illustration (C) of how the markings on the defendant's little finger occurred. *(Norman D. Sperber, DDS, San Diego, California, and El Cajon Police Department, El Cajon, California.)*

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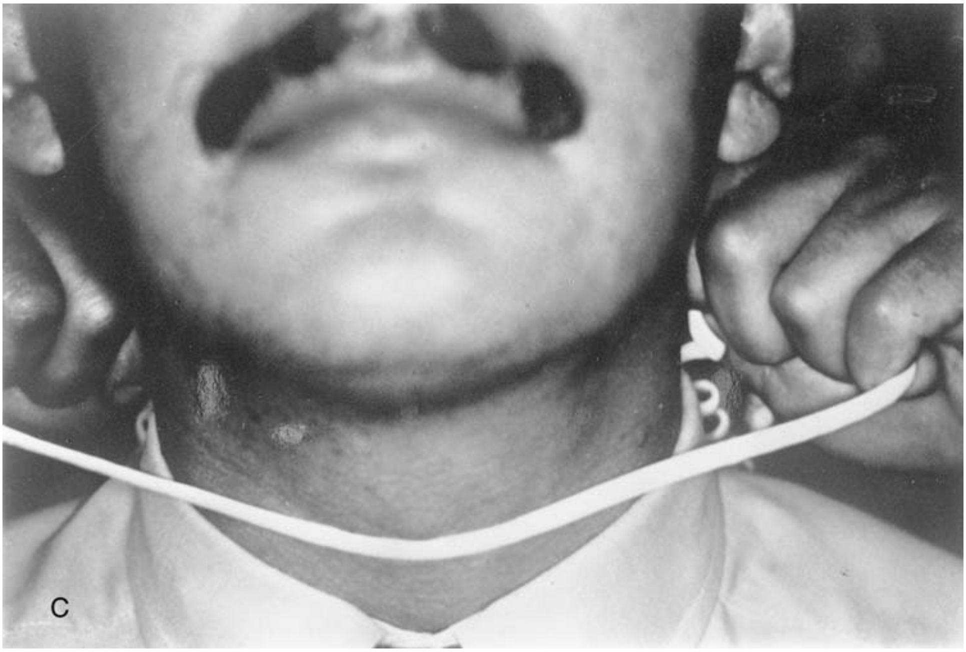

Figure 9.6 (continued)

Figure 9.7 A 4-week old infant was bitten by the family pet (A). The Great Dane's teeth (B) were compared with a cast of the wound (C). (*Los Angeles County Department of Coroner.)*

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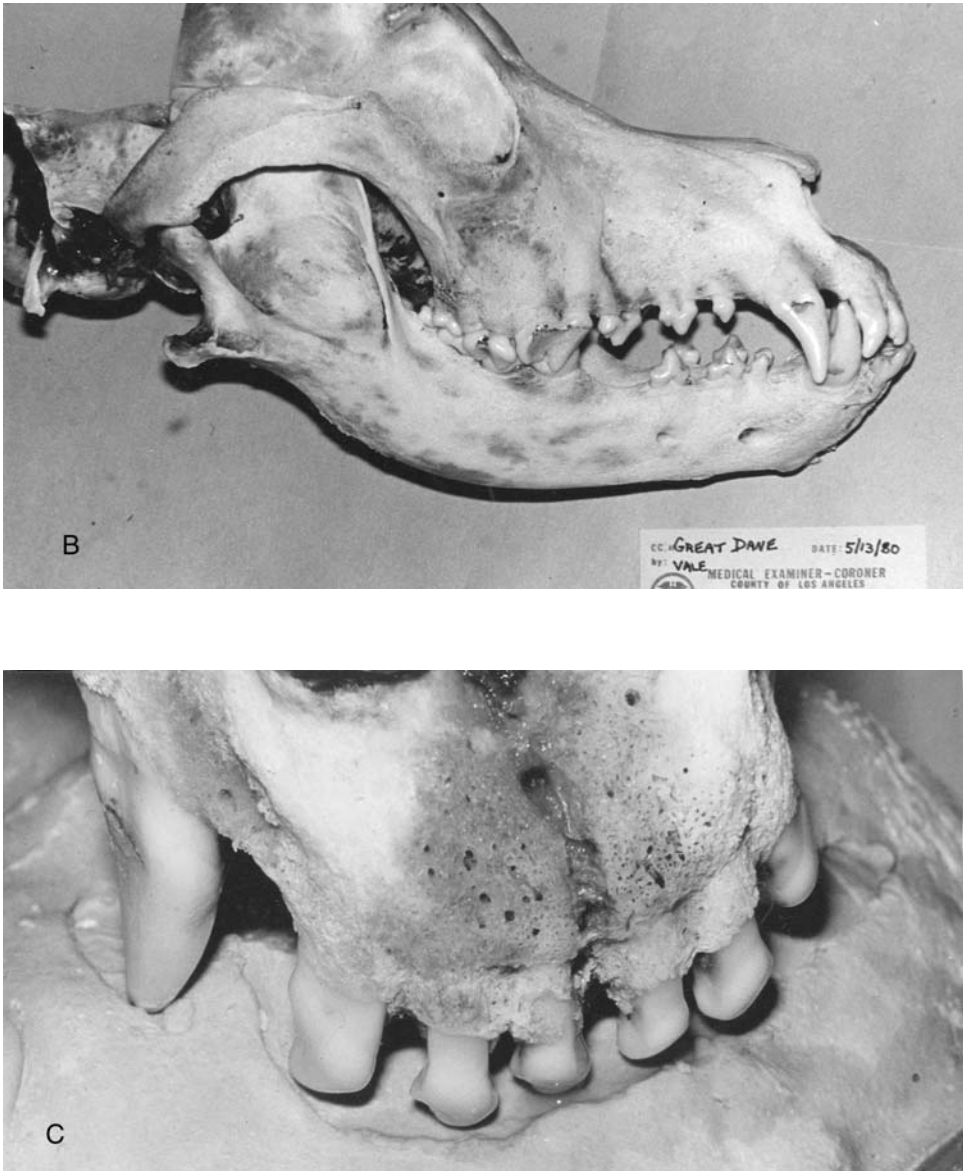

Figure 9.7 (continued)

Preservation of Footwear and Tire Impressions

Although the focus here is on footprints, much of what follows concerning preservation and collecting this type of evidence applies equally well to tire impression evidence.

Foot impressions are generally found outdoors; the first precautionary measure is therefore to protect the impression from alteration or destruction, preferably by covering it with a box or cordoning off the area. Impressions in thawing snow are especially troublesome, so a box covered with snow to prevent thawing should protect them. If a foot impression is in such a position that it is possible for it to gradually fill up or be damaged by running water, it must be surrounded by a wall of earth, sand, or snow; alternatively, a hole may be dug close to the impression and the water drained toward the hole. However,

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these protective measures are only stopgaps and the actual preservation should be undertaken as soon as possible.

Footprints on Floors

Interior locations often have footprints present, especially on surfaces such as tiled floors, glass, desktops, counter tops, and chair seats. A simple procedure to locate these indoor prints is to turn off all the interior lights and, by means of a high-intensity flashlight, search the surfaces by shining the light at a low angle. Often these impressions are dust prints and very easily destroyed. Once detected, care must be taken to make certain they are preserved.

Preservation of Footwear Evidence

Preservation should be done by *photographing* and *casting* or, in the case of dust prints, by *lifting*.

Photographing Footwear Impressions

The most common errors made in crime scene photography involve taking photographs of shoe and tire impressions that result in poor-quality photographs. Reasons for this include: not using a tripod to support the camera, not shooting perpendicular to the impression, failing to use a scale or ruler in the photograph, and not using oblique lighting. Overall, taking quality photographs is relatively simple, but it requires practice.

The camera should be placed *vertically* above the impression on a tripod with a scale placed next to the impression. The film plane should be parallel to the impression so as not to cause distortion in the photograph. It is good practice to place two scales in the photograph at right angles to each other. One rule can be placed adjacent to the long axis of the foot impression and a second perpendicular to the first, in the region adjacent to the heel.

Although large format cameras, e.g., 4- × 5- or 2-inch formats, allow for larger negatives, 35-mm cameras have become more widely used for crime scene work and produce acceptable results. The quality of today's photographic films is very good. Footwear and tire impressions require film that can capture fine details; therefore, fine-grained films will be best for this purpose. Black-and-white and color photographs should be taken of the prints. High-resolution digital cameras can also provide good results; however, moderately priced cameras may not produce the desired photographic quality for impression examination.

If the bottom of the impression is appreciably deeper than the surface of the ground or snow, the scale should be brought down to the same level. Before photographing, any material that may have fallen into the impression after it was formed should be cleaned away. For this purpose it is convenient to use tweezers, a piece of paper onto which lumps of earth are rolled, or other such objects that cannot be picked up by the tweezers. If it is not possible to carry out this cleaning without injuring details of the impression, it should be omitted. Materials trampled into the impression, such as leaves or grass, should not be removed because they form part of the impression and no details will be found under them. Careless removal of a trampled blade of grass can destroy large parts of the impression. Any water that may be present should be carefully removed by a hypodermic syringe

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or small pump. If a foot impression has been made in snow, it may be difficult to get a clear picture of it. Hard snow may be dusted with aluminum powder, which gives a clearer picture. With loose snow, aluminum powder can be dusted into the mark by tapping the brush.

Because the details in foot impressions are three dimensional, the photograph should be made under illumination that will bring out those details to the best advantage. Direct sunlight enhances the details by creating highlights and shadows. When the sky is cloudy and the daylight diffuse and practically without shadow, artificial light must be used; photoflood or flash illumination is suitable. These considerations, of course, also apply to situations in which it is imperative that the pictures be taken at night. The important point to remember about the illumination is that the light must not be held at too low an angle because too much shadow will obscure rather than emphasize detail.

Casting footwear impressions is generally done with dental stone. Other materials include paraffin, sulfur, and silicone rubber,[3] which are less frequently used.

Casting with Dental Stone

Dental stone is a type of gypsum or calcium sulfate that can be used to cast shoe and tire impressions. At one time, plaster of Paris was more widely used for this purpose; however, dental stone is superior and readily available from dental supply companies. Dental stone can be used for casting most impressions, even in snow.

Foot impressions in loose, dry sand and earth can be taken without any special preparation. Some literature suggests removing loose twigs and leaves, but this practice can damage the impression and is discouraged. Also, using fixatives such as spray lacquers or talc, practices generally recommended for use with plaster of Paris, is not necessary with dental stone.

Casting Water-Filled Impressions

Dental stone lends itself quite well to casting water-filled impressions. If an impression is very muddy or filled with water, no attempt should be made to remove the water because this may damage the impression.

A retaining wall or frame should be placed around the impression. The retainer should allow for a cast of at least 2 inches in thickness. Dental stone is lightly sprinkled or sifted directly into the water-filled impression to about an inch thickness, followed by normally prepared dental stone that has been prepared with a little less water and is slightly thicker. The cast should be poured to about 2 inches thick and allowed to set in place for an hour.

To cast a footprint, about 2 pounds of dental stone in about 12 ounces of water is used. A clean rubber bowl can be used for mixing. Water should first be added to the bowl followed by sifting in the dental stone. The mixture should be stirred to remove any lumps and air bubbles. The final mix should be the consistency of pancake batter. An alternative method is to use a zippered plastic bag to carry about 2 pounds of dental stone and to mix the material right in the bag. This procedure is reported to be very convenient to use. (Note that when dental stone is mixed with water the solution heats up. This heating causes difficulties when casting impressions in snow. For this reason, a small amount of snow or

[3] Casting impressions takes practice. It is recommended that one develop skills by working on nonevidentiary footmarks with the material, whether dental stone or any of the other techniques.

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ice should be added to the mixture to keep the temperature down, and the mixture should be made slightly more viscous than pancake-batter consistency.)

After the material is mixed it should be gently poured onto an area adjacent to the impression and allowed to flow onto the impression. If it is necessary to pour the material into the impression, a baffle such as a flat stick or spoon can be used to lessen the impact of the material. Great care needs to be taken that the dental stone does not destroy any of the fine material in the impression. Before the cast hardens it should be marked, using a twig, scribe, or other sharp instrument, with information including the date, investigator's name or initials, case number, and location of the impression.

The material will harden sufficiently for removal in about 30 minutes. Clumps of soil and rocks clinging to the cast should not be disturbed and the cast should be allowed to air-dry thoroughly for about 48 hours. If the impression is deep and firmly seated it should be carefully excavated so that it finally lies on a pillar that may then be cut off.

Casting Impressions in Snow

When casting impressions in snow, the impression is prepared first by spraying a thin layer of Snow Print Wax® (available from a number of law enforcement supply companies). The print should be photographed a second time after the application of the Snow Print Wax spray. After the applications of spray have been applied to cover the print completely and then allowed to dry, the dental stone is carefully poured into the impression. The stone is prepared with cold water and snow and should be made slightly thicker than normal. The material should be allowed to set up for at least an hour before removal and should dry for about 48 hours (Figure 9.8).

Sulfur casting is another procedure used by some for snow prints. About 5 pounds of powdered sulfur is needed for a print. The sulfur is melted in a 1-quart aluminum pot and poured into the print, using a channel to direct the flow of the molten sulfur. The trick to using sulfur is not to heat the material too much. Sulfur melts at 115°C but, if heated to 170°C, it changes characteristics and cannot be used. For best results, it should be heated slowly and continuously stirred. The molten sulfur must be poured quickly because it will solidify as soon as it comes into contact with the snow. The cast should remain in place for about an hour; because it will be very fragile, extreme care must be taken when handling it (Figure 9.9).

Preservation of Footprints (Dust Prints)

Footprints are *always* preserved by photographing. After this is done, one of the following methods should be applied:

1. **Recovering the object on which the footprint is made.** Footprints are often found on objects stepped on by the criminal (entering in the dark through a window, for example). If the window is broken, all fragments of glass should be examined. This type of print is usually best detected by low-angle illumination from one side. Rubber heels and soles leave exceptionally good prints on glass. Detailed prints are often also found on paper or cardboard that may be strewn about the room during a safe burglary. All such loose objects bearing prints should be carefully preserved for transport to the laboratory. When the seriousness of the crime warrants it, and

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Figure 9.8 This dental stone tire casting was taken in a case involving the theft of several airplane propellers that was investigated by the Anchorage Airport Police. The tire impression was the first cast that the officer had ever poured in snow and enabled an easy identification because the tire had several bent studs. The technique used in Alaska in snow casting is to spray the impression first with gray automobile primer, which gives good contrast for photography and acts as a shell for the dental stone. The dental stone and water need to be ice cold prior to mixing. In extreme cold, potassium sulfate is added as an accelerator to the water and has been successfully used to cast impressions in conditions well below zero. *(Alaska Department of Public Safety, Scientific Crime Detection Laboratory.)*

when the print consists of a dried liquid such as blood or ink, it may be advisable to remove a portion of linoleum or floor tile that bears a clear impression.

2. **Lifting by a special lifter** is preferred whenever dust or a dust-like substance holds the print from the shoe. The lifter is a sheet of black rubber with a slightly sticky surface that is pressed against the print, picking up a faithful replica of the whole print. Oblique light photography under laboratory conditions brings out this dust print to a contrast often better than that observed in the original print. If a sufficiently large *fingerprint lifter* is available, it may be used instead of the special lifter. Care must be taken not to stretch the rubber lifter because the dust image may become distorted.
3. **Lifting by photographic paper** may be employed when special lifters are not available. Black (exposed, developed, fixed, and washed) or white (fixed and washed) photographic paper is used, as determined by the color of the material in the print.

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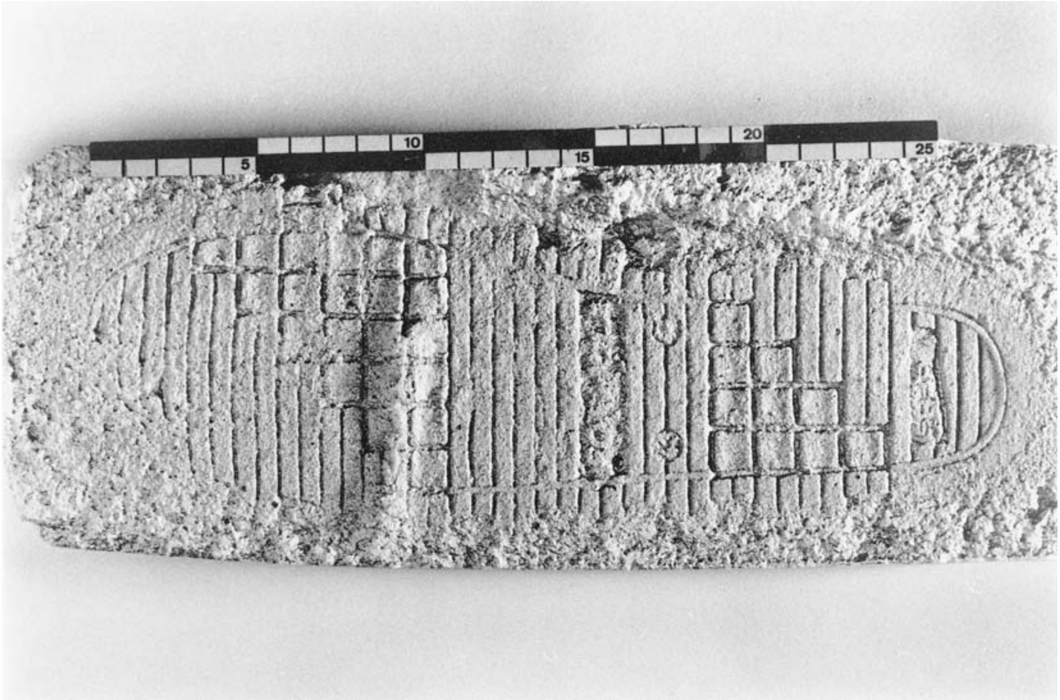

Figure 9.9 A plaster cast from a shoe impression in snow showing good detail of the shoe sole pattern. The cast surface has been "colored" with silver spray to enhance the detail for photography. *(Zurich Cantonal Police, Forensic Science Department.)*

The paper is dampened with water or dilute ammonia, laid emulsion side down over the print, and beaten against the print with a stiff brush or clapped with the palm. When the whole surface has been thoroughly beaten, the paper is removed and laid out to dry.

4. **Lifting by static electricity** is another technique (Figure 9.10). Companies selling evidence collection equipment also sell field kits called electrostatic dust print lifters, which pick up dust prints onto Mylar-coated foil by means of static electricity. This procedure has applications in certain situations in which suspects walked on tile floors.

Taking Comparison Footprints from a Suspect

When the original prints are from covered feet, e.g., shoes or sneakers, the examiner who makes comparison shoe prints should wear them. When *comparison footprints* are taken, the soles are coated with water-based ink using a large inkpad. The inked shoes are then carefully stepped onto a sheet of tracing paper or acetate sheet.

In taking prints of bare feet, the feet are blackened by pressing them against a thin layer of printing ink. In order to get a true picture of the formation of the sole of the foot in different positions, four different prints are taken: normal standing position, standing position with pressure against the outside of the foot and with pressure against the inside, and finally when walking. This also applies to stocking feet.

Yet another method for obtaining known footwear exemplars involves using talcum powder and black carbon paper. A thin coating of talc is spread on a sheet of newspaper

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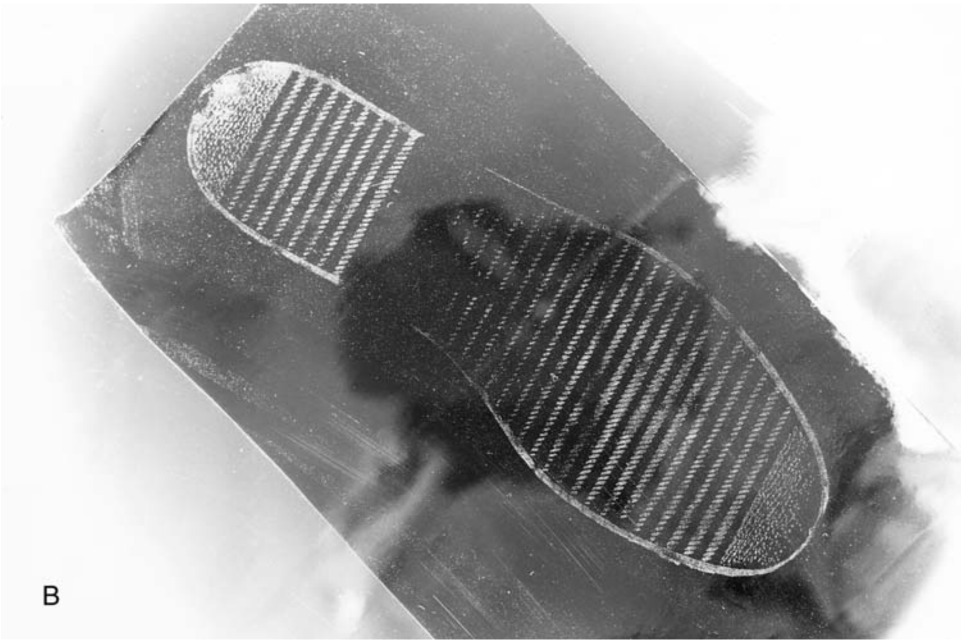

Figure 9.10 An electrostatic dust print lifter (A) and a dust print (B) lifted by the technique. *(Kinderprint Company, Martinez, California.)*

placed with talc side up on top of about 10 sheets of newspaper that act as a cushion. The shoe is placed on the foot and walked onto the talc-covered newspaper. The talc-covered shoe is then impressed onto the carbon paper, carbon side up. The carbon paper is similarly cushioned with about 10 sheets of newspaper. The resulting print is photographed 1:1 using Kodalith™ high-contrast copy film. The developed negative will show a positive reproduction of the impression that can be superimposed over a negative from the crime scene.

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Comparison of Footprints

Comparison between footprints found at the scene of a crime and those of a suspect should be made by an expert, but this does not prevent a police investigator from undertaking a preliminary examination.

Prints or impressions of shoe-covered feet are seldom the same size as the shoes; even when they are made, slipping and the movement of walking can damage prints. The mark of a naked foot in movement can be as much as 1 inch longer than the mark of the same foot in the standing position. A foot impression in wet earth can become appreciably smaller when the earth dries; in clay, the length can decrease by up to 3/4 of an inch. Thus, in establishing identity, too much significance should not be attached to dimensions. When examining the mark of a shoe-covered foot, the circumference characteristics should be checked. If the marks from the scene of the crime and from the suspect are similar in form, it is less important that they may differ somewhat in size.

Identification is based mainly on characteristic marks on the sole or heel. The examination is best done by direct comparison of the preserved footmark from the scene of the crime with the foot covering of the suspect. These are photographed side by side and characteristic points are marked. With footprints, however, it is generally convenient to take a print of the foot covering of the suspect and compare the prints. When it is a question of prints of bare feet, an examination is made first to see if there are any identifiable friction skin patterns and, if this is the case, the investigation is carried out as for finger and palm prints (Figure 9.11).

In examining the foot covering of a suspect, dust, dirt and earth should be kept and, if necessary, compared with similar materials at the scene of the crime. If the perpetrator has left overshoes at the scene, they may be compared with a suspect's shoes. Characteristic marks on the shoes, particularly on the soles, may be reproduced inside the overshoes; for this examination, the overshoes must be cut open. If a shoe is found at the crime scene, it may contain characteristic marks of wear from the owner's foot. Such marks can then be compared with the markings inside shoes that can be shown to have been worn by the suspect.

Marks on Clothes and Parts of the Body

If clothing is pressed against a smooth surface, a latent print may be produced. Such a print is developed in the same way as a fingerprint or glove print. Clothing contaminated with a foreign material such as blood can also form a print. When clothing comes into contact with a plastic substance (e.g., clay), an identifiable plastic impression may be formed in it.

Fabric Marks

When a mark from clothing is to be recorded, it must be photographed with the camera placed vertically above or centrally in front of the mark. A scale must be placed at the side of the mark. If the mark is sufficiently large, the scale may be placed in the center of it. In such cases, a number of pictures should be exposed and the scale should be moved to either side for each exposure so that details are not concealed.

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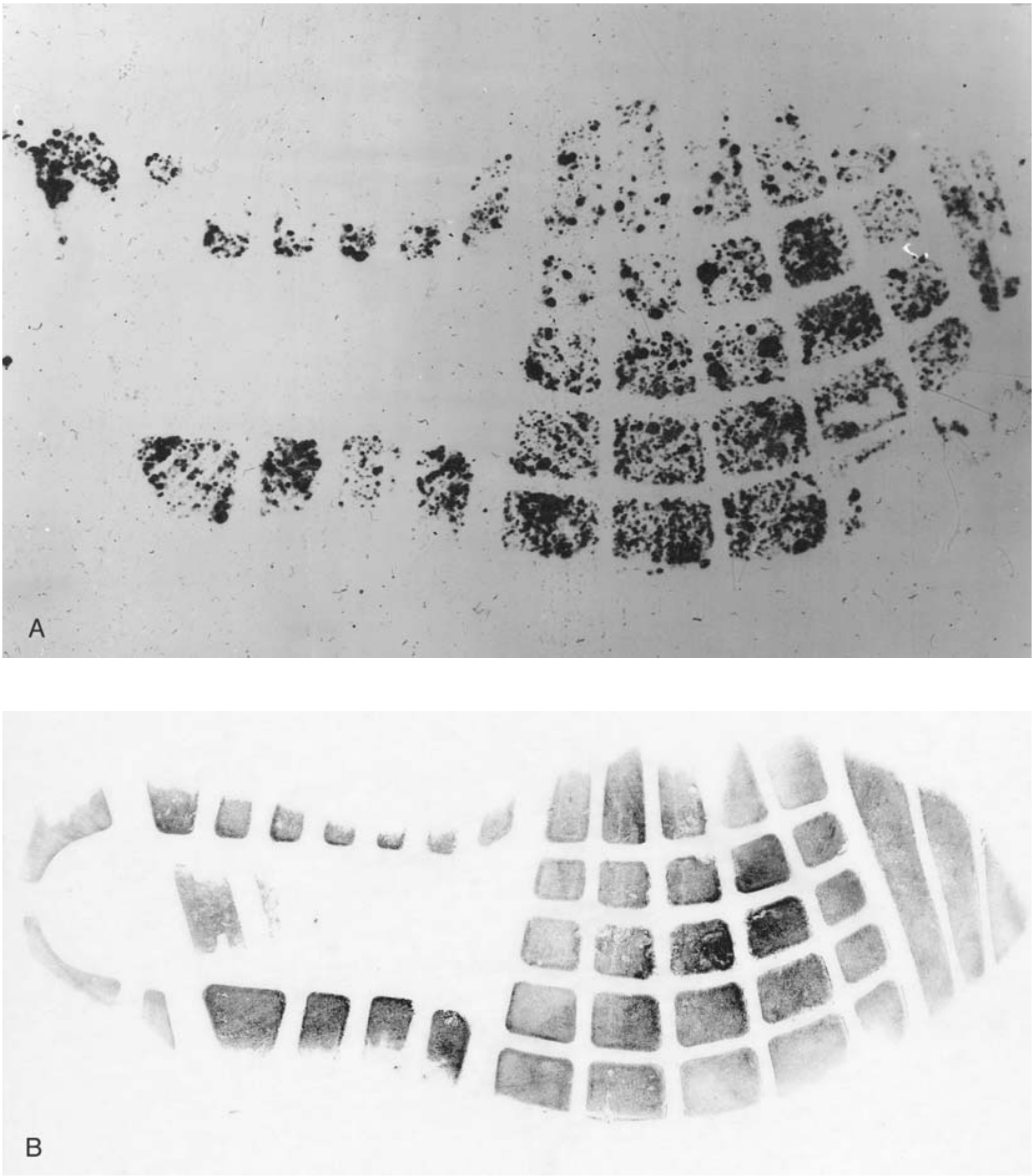

Figure 9.11 This footwear impression (A) is a photograph of a luminol reaction in a double homicide in Nome, Alaska. The impression was completely invisible prior to the application of luminol and matches the test shoe impressions of the suspect (B). *(Alaska Department of Public Safety, Scientific Crime Detection Laboratory.)*

Marks of clothes are identified with the aid of the structure of the fabric, faults in the fabric, seams, patches and other repairs, damage, and the like.

Sometimes a whole section of the body forms impression marks from a body print or impression. In one case, a burglar fell from a water spout onto the damp earth below, making an impression that showed clearly the face with a characteristic nose and both hands, one holding a crowbar and the other a pistol. When a hand has made a print or impression on a plastic medium, one should look for identifiable friction skin patterns.

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Figure 9.12 A suspect picked up a prostitute and, while in her room, produced an Australian Federal Police badge (A), hoping to get some free "service." The prostitute retaliated and was assaulted. The badge was a facsimile in a clear plastic wallet. The suspect discarded the badge, which was subsequently located by police; the plastic wallet was found in the possession of the suspect. An examination of the wallet revealed the outlines of a badge (B) of similar size and shape to the one found at the scene. *(State Forensic Science Laboratory, Melbourne, Australia.)*

Other marks may also be found such as those of rings, injuries, characteristic skin wrinkles, hand coverings, and so on. The preservation of marks of parts of the body is done in the same way as for footprints.

Tooth Marks

Tooth marks may leave compression or scraping marks and can occur in butter, cheese, fruit, chocolate, and the like (Figure 9.13). Bite marks may also occur on the skin of victims of rape or sexual murder, or on a criminal. Cases have occurred in which the criminal has become involved in a hand-to-hand fight and a tooth has been knocked out or a dental plate broken, and parts of the tooth or the dental plate have been found.

Bite marks can, at times, be so characteristic that they make possible the definite identification of a suspect. The relative positions of the teeth, their width, and the distance between them, together with ridges on the edges of the teeth and grooves on the back or

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Figure 9.12 (continued)

front, vary for different individuals and may show in the bite mark. Deformations resulting from injuries or illness in the form of portions broken away, characteristic wear of the teeth, fillings and other dental work, and the loss of certain teeth are noted in the bite.

Generally, tooth marks come from front teeth in the upper and lower jaws. With children and young people the edges of the front teeth usually have three ridges (at times more) that are distinguished by shallow incisions, sometimes in the form of furrows, continued on the front and back sides of the teeth. With increasing age, these ridges and furrows generally disappear so that by age 30 the front teeth are generally smooth.

The Preservation of Bite Marks

Bite marks should be carefully preserved by photographing and casting. They are generally formed in material that cannot be sent away or kept for a long time without the mark changing in appearance due to drying or decomposition of the material. Marks made in fruit can be preserved in 0.5% formalin solution, which prevents changes resulting from drying, decay, and so forth. However, it is not advisable to leave the fruit in solution for shipment by mail to an expert because it may be broken up and mixed with the solution as the result of shaking. An apple showing a bite mark that is to be sent for examination should instead be fixed by soaking in the solution for several hours, and then wrapped in tissue paper moistened with formalin solution. The whole package is then packed in a carton or box.

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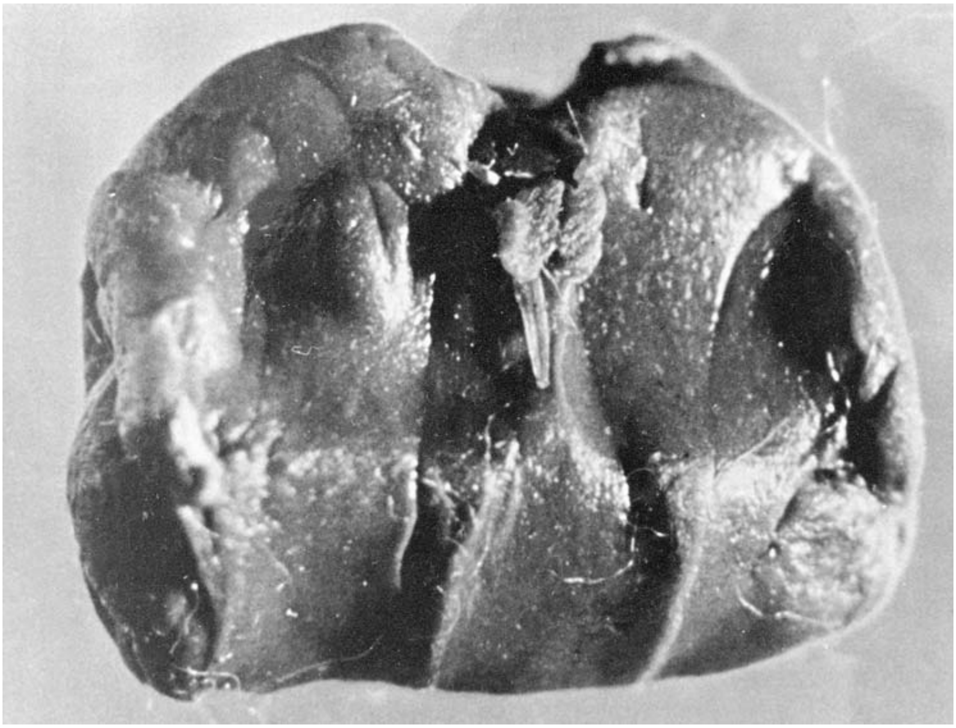

(A)

Figure 9.13 In a homicide case involving two suspects, a wad of used chewing gum (A) was discovered at the crime scene. Dental impressions of the victim and suspects were made (B) and compared with the gum. An unusual feature of the gum's impression was a defect corresponding to an opening drilled in the back of one suspect's upper incisor during root canal therapy. In a further comparison, blood typing revealed a blood type that was the same as that suspect's. The case resulted in a guilty plea to second-degree murder. *(Norman D. Sperber, DDS, Forensic Odontologist, San Diego, California.)*

For photography, oblique lighting is used so that details appear most clearly. It should be noted that there is a risk that, for example, butter or soft cheese might melt under the heat from a photographic lamp. All bite marks should be photographed before casting because the casting may go wrong and bite marks are generally altered in such a way that a fresh cast cannot be taken.

Casting Material for Bite Mark Evidence

The casting material must be chosen with regard to the properties of the material in which the bite has been made. If the material contains water-soluble substances, e.g., chocolate and certain types of cheese, then the bite mark should be isolated from the casting mass by spraying it with a thin layer of collodion or the like. Suitable casting media for different materials are described next.

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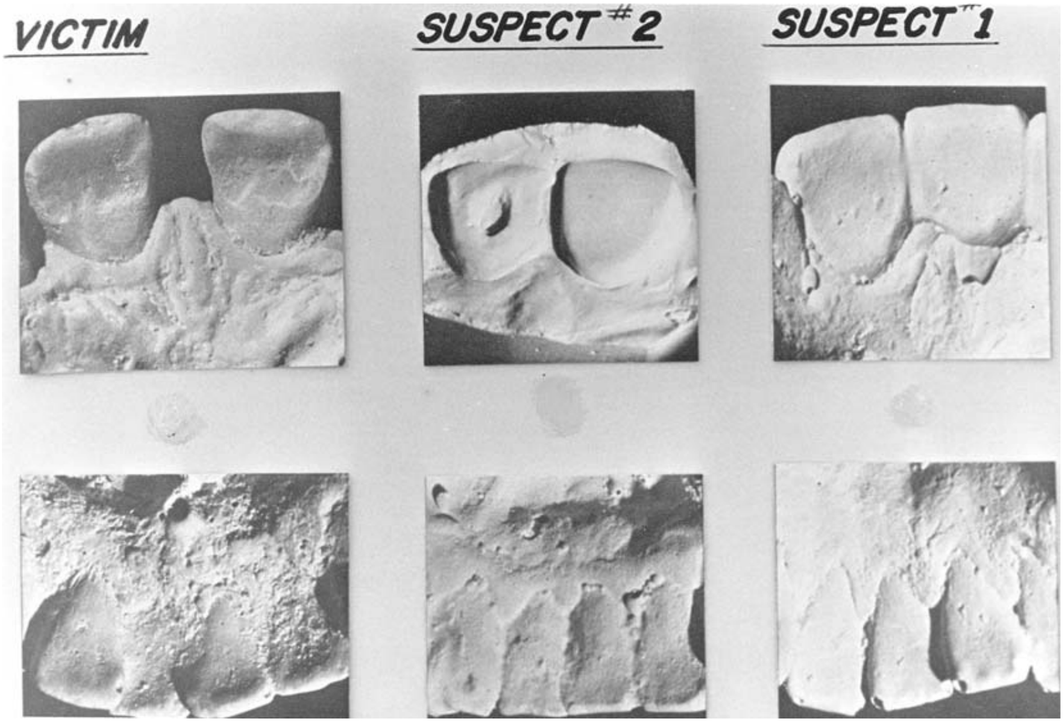

(B)

Figure 9.13 (continued)

Human Skin

Bite marks should first be photographed with a scale; those found on skin should be traced using clear cellulose acetate and a felt-tip marker. The quality of the cast impression will depend upon the depth of the bite. Silicone or rubber-based dental impression creams may be used to cast the impression. Because saliva may be present as part of the mark, a swab of the area should be made for DNA typing.

Foods

Bite mark impressions may be left in cheese, butter, sandwich meats, fruit, chocolate, chewing gum, and other such foods. If the food is water soluble, dental impression cream such as polysulfide rubber-based impression materials may be used. Other materials such as plaster and molten sulfur (provided that the material is not heat sensitive) have applicability. If dental stone is used, the surface should first be lightly sprayed with lacquer or similar material if the item to be cast contains water.

Tool Marks

Marks of tools or of objects that have been used as tools are often found at the scene of a crime, especially in cases of burglary. Marks may have been left in wood, metal, putty, or paint. Among the tools that leave identifiable marks are axes, knives, screwdrivers, chisels, crowbars, pliers, cutters, and drill bits. Some of these tools may be homemade.

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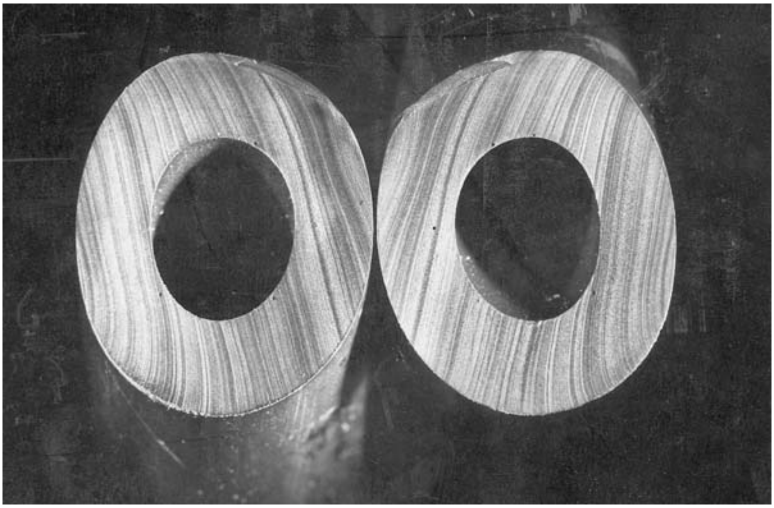

Figure 9.14 A stolen outboard motor was identified by comparison of the tool marks made when the rubber gas lines between the portable tank and motor were cut. *(Center of Forensic Science, Toronto.)*

These marks are essentially of two types: those in which only the general form and size of the tool are apparent and those in which injuries, irregularities, and other peculiar characteristics are reproduced in the form of striations or indentations. Marks of the first type may not make a definite identification of the tool possible, but do serve as a guide when it is necessary to decide whether the tool of a suspect *could* have produced the marks. Tool marks that show striations, indentations, or similar details resulting from damage or other irregularities in the tool are the most valuable as evidence.

Preservation of Tool Marks

Whenever possible, tool marks should be kept in their original condition. This may be done by recovering the whole object, or part of the object on which the marks appear. Sometimes, it can be arranged that the marks remain untouched at the scene of the crime but can be recovered later if this is required. This is permissible, however, only when the marks are in such a position that they are completely protected, for example, a small mark on the inside of a door or window frame. If a mark in metal is not immediately recovered, it should be covered with a thin film of oil to prevent oxidation. In recovering the mark, it is important that it be protected against dirt, moisture, and scratching during transport. Tissue or other soft paper should be placed over the tool mark in packaging.

Casting Tool Marks

Casting or other methods of taking impressions of a tool mark should be used only as a last resort. No matter how good a cast is, it can never be equal to the original. This applies especially to marks made in soft materials such as wood, putty, and paint; many of the casting media most suited for these materials are unable to reproduce all the finer details important for identification. Experiments have shown that an impression or a cast cannot reproduce scratches in paint caused by extremely small irregularities in the edge of a tool. Consequently, a microscopic comparison of the cast with a mark made from the suspected

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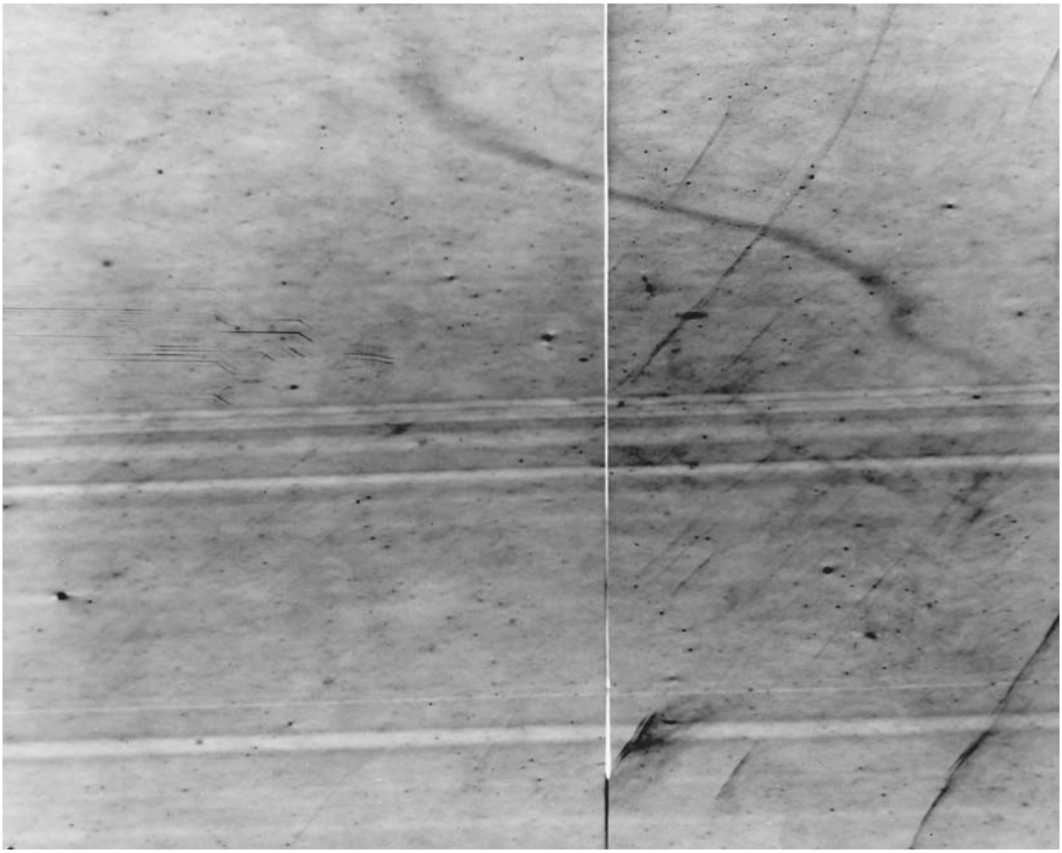

Figure 9.15 Consecutive manufacture comparison marks of plastic trash bags in a murder case proved to be important evidence. The photograph depicts a single layer of two plastic bags placed edge to edge. Characteristic "die line" and homogeneous mixing in the original plastic sheet are continuous between individual bags. These bags were used to link a box of trash bags from a residence and bags from the alleged crime vehicle to two bags found at the murder scene. *(Oklahoma State Bureau of Investigation.)*

tool may not lead to any positive results. If, however, the original mark is compared with one made directly by the tool, then a positive identification is possible.

In the casting of marks, however, very satisfactory results may be obtained with dental impression materials or silicone rubber, and the completed cast will show fine detail.

Difficulties and some expense may be involved in taking possession of the original tool mark. Therefore, it should be subjected to a close examination with the aid of a magnifier in order to make sure that it shows typical details from the tool before any further steps are taken. In each particular case, consideration must also be given to the type of crime, value of the object, whether or not a tool from a suspect is available or the probability that such a tool may be found, etc.

Whether the actual mark is recovered or a cast is made, the tool mark should be photographed whenever practical. The picture should show clearly the location of the mark in relation to the rest of the object. Close-up photographs are generally taken in cases in which the mark may be destroyed in the casting process or during removal. The photographs must be made with the film plane parallel to the mark and should include a scale.

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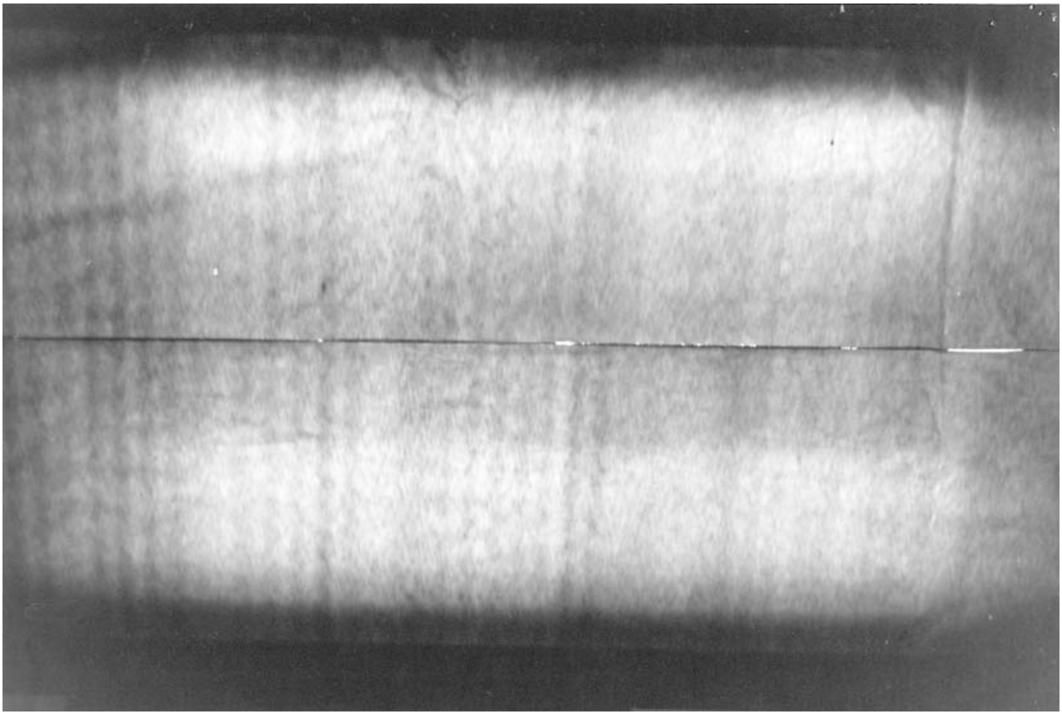

Figure 9.16 The residential community of Castleton, New York, was shocked by the brutal stabbing and bludgeoning of Carolyn J. Finkle, a 42-year-old resident of Rensselaer County. Her two teenage daughters were extremely distraught and claimed they had found their mother slain with multiple stab wounds. Detectives mounted an intensive investigation. Plastic garbage bags used to wrap the murder weapon found in a dumpster matched bags found in the victim's house. The photograph shows backlighting of the plastic bags, revealing sequential striations caused by the manufacturing process. The daughters subsequently confessed to the crime. *(New York State Police Crime Laboratory.)*

Oblique lighting is used to enhance details in the mark. Close-up photographs should be in actual size, if possible, or in the case of smaller marks, enlarged. It is generally not possible to identify the tool used from photographs.

Trace Evidence on Tools

In connection with all tool marks and suspected tools, it should be remembered that the tool might also have deposited traces in the form of paint, oil, or other contamination. In turn, clues in the form of wood fragments and paint from the object may be found on the tool. These traces are sometimes just as valuable as the tool mark. Samples should therefore always be taken from the area of the tool mark whenever the actual mark is not recovered. Valuable tool marks are also sometimes found on splinters of wood, loosened flakes of paint, and chunks of safe insulation.

During the examination of the crime scene, the possibility should always be kept in mind that any tool mark found might be compared with marks from previous crimes. It happens frequently that identity is established among tool marks from different burglaries long before the criminal is apprehended or the actual tool is found.

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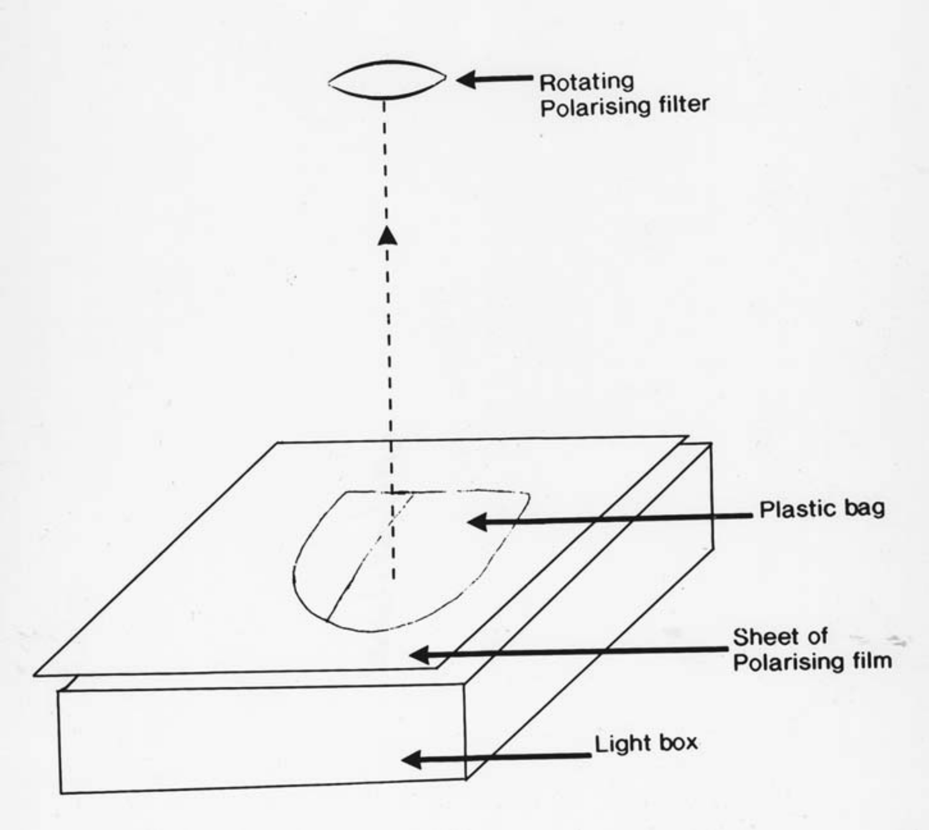

Figure 9.17 The Forensic Science Service uses a slightly different technique from that of the New York State Police Laboratory shown in Figure 9.16. A sheet of polarizing film is placed on a light box and under a plastic bag. A polarizing filter is rotated so as to view interference patterns on the plastic. *(Forensic Science Service, United Kingdom.)*

The investigating officer should always endeavor to imagine being in a similar position to the criminal when the tool marks were made to consider how the criminal held the tool, stood, or was supported when breaking in or prying open. A burglary may be faked with the object of concealing embezzlement or of defrauding an insurance company; therefore, the investigator should always examine the opposite part of a mark (e.g., in a doorframe). The fake burglar often overlooks the fact that this other part of the mark must be present.

Moreover, it is essential for the expert who is to carry out the comparative examination of the tool and the tool marks to understand how the criminal held the tool when making the marks. In most cases, if the examination is to have any prospect of leading to the identification of the tool, the expert must make a comparison mark in exactly the same way as the criminal has done. This applies especially to those tool marks that show scratches resulting from damage or other irregularities in the tool. The distance between the scratches varies according to whether a knife, for example, is held at right angles to its direction of movement or is held askew; the appearance of the scratches depends on the angle taken by the knife in relation to the plane of the cut. It is best if the position of a "fixed" mark and the conditions at the place are shown to the expert in a sketch or a comprehensive photograph. A statement that the suspect is right- or left-handed should be added.

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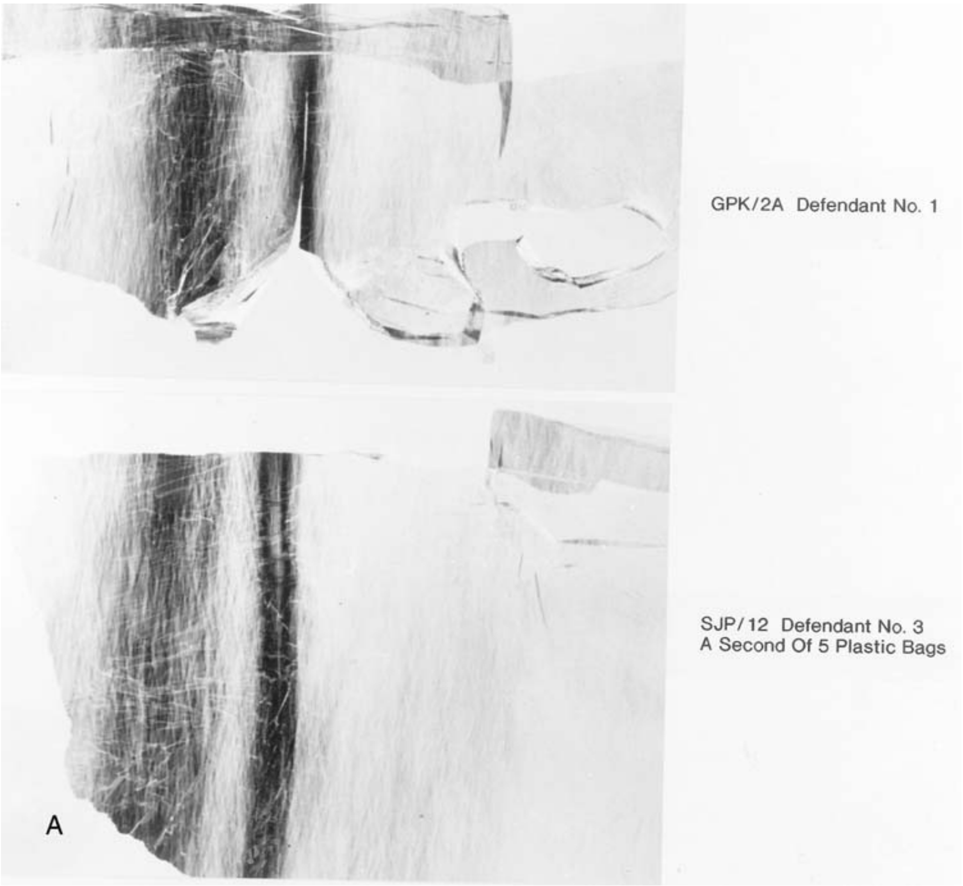

Figure 9.18 Following a long-term drug investigation (A and B), three defendants were arrested and charged with conspiracy to supply and import heroin. Part of a plastic bag (GPK/2A) with brown powder was recovered from female defendant, No. 1. A plastic bag (WB/1) with brown powder was recovered from male defendant, No. 2. Five plastic bags (SJP/12) and some condoms with brown powder were recovered from male defendant, No. 3. The brown powder was analyzed and found to be heroin; the condoms were found to have vaginal epithelial cells present. It was believed that the female smuggled the heroin secreted in her vagina and handed it over to defendant No. 3 for the purpose of supply. The plastic bags were examined by transmitted polarizing light and observed through a rotating polarizing filter. A pattern of interference bands was observed; this property originates in the manufacturing process. In some makes of bags the interference pattern is continuous through several bags, while in others the pattern tapers out within the length of one bag. Of the five bags in SJP/12 (Defendant No. 3), different patterns showed on at least two. One was found to be the same as the bag in WB/1 (Defendant No. 2), and another was found to be the same as bag GPK/2A (Defendant No. 1). The evidence was able to link all three defendants. *(Forensic Science Service, United Kingdom.)*

It is essential that the comparison mark be made in the same material as the mark at the scene of the crime (with the same paint or surface treatment, of the same degree of moisture, etc.) because the clarity of definition of the microscopic scratches varies with different materials. Thus, a quantity of material for use in producing comparison marks should be sent with the tool and tool mark — it may be necessary to make 10 or more such marks with the suspected tool.

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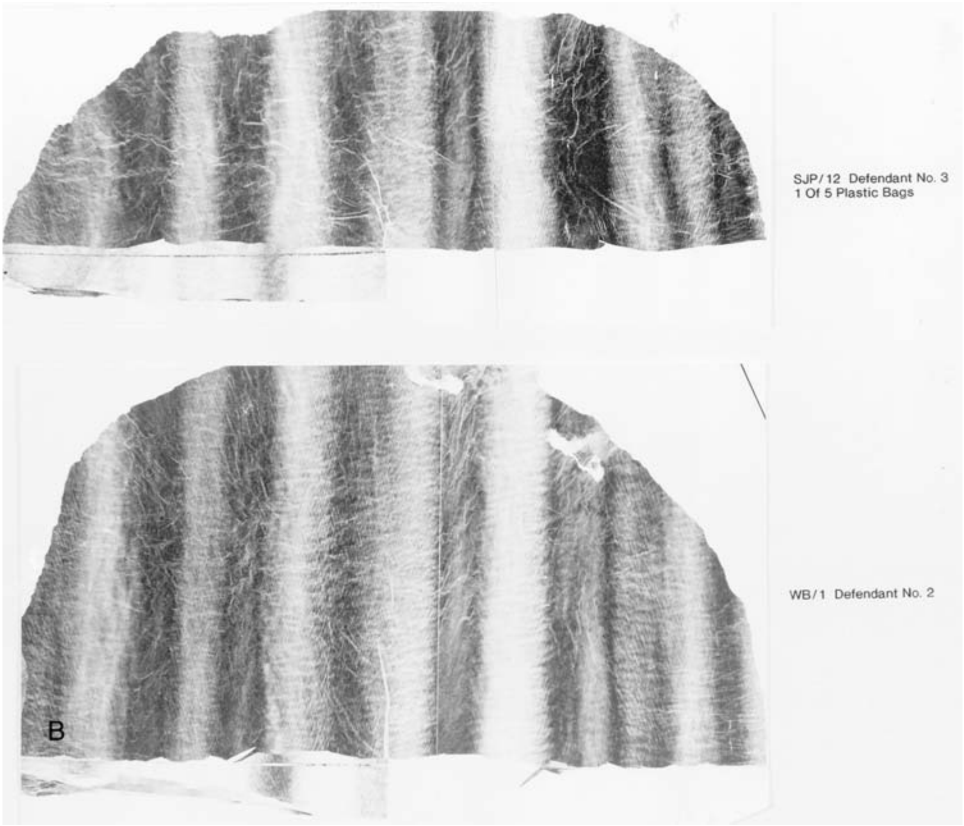

Figure 9.18 (continued)

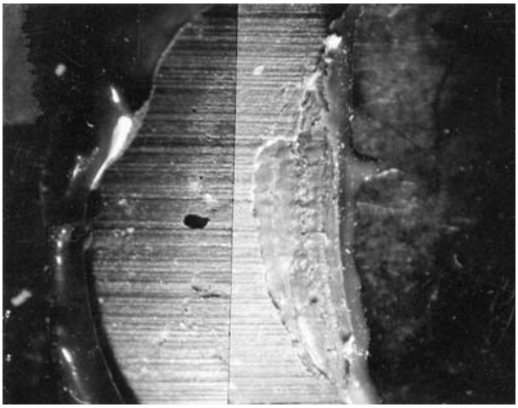

Figure 9.19 A young girl was found stabbed to death on her bed. A search of the crime scene uncovered a broken fingernail in the vicinity of the bed. Fingernail clippings were collected and a comparison was made on silicone rubber castings of the underside of each nail, using reflected, oblique lighting. The examination established that the broken nail came from the victim. *(New York State Police.)*

The police officer should not attempt to fit the tool into the mark or make a comparison mark with a suspected tool. In most cases, the officer does not have access to an instrument suitable for closer examination of the character of a tool mark, which may be necessary

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Figure 9.20 Physical match can be made on a wide variety of objects. In this case, pieces of a broken automobile antenna are shown pieced together. *(Los Angeles County Sheriff's Department.)*

in order to decide how the comparison mark is to be made. Also, traces of paint or foreign metal on the tool, only observable with a microscope or powerful magnifying glass, may be lost or the tool may be damaged.

Casts or impressions of tool marks should be packed in such a way that they cannot be altered or destroyed during transport. Positive casts should never be made because this may cause fine details to become obscured. If the negative cast of the mark might be destroyed in transmission, it is best to make two and to keep one in reserve.

Regarding boring marks, only wood bits and certain spiral bits generally leave identifiable marks. The bottom of the boring, if there is one, and boring chips are important. With other types of bits, identification is possible only in the most favorable cases and then as a rule only when the bottom of the boring is present.

At times, the police officer comes up against the problem of deciding, for example, from which side of a window frame (outside or inside) a hole has been bored. In most cases this can be seen from the more or less loose wood fibers around the entrance and exit holes of the bit, but with some bits it may actually be difficult to decide the direction of boring. Reliable information is obtained by cutting through the surrounding wood in the longitudinal direction of the hole — by first sawing through the wood around the hole from each side up to about 1/2 inch from the hole, and then breaking the wood apart. It will then be found that the wood fibers are directed upward from the hole in one edge of each half and downward in the other edges. The wood fibers around the boring are displaced in the direction of rotation of the drill, so upon cutting the boring into two parts in this manner, they reveal clearly the direction of boring. The degree of orientation of the wood fibers varies for different types of bits and it is possible to obtain an idea of the type of bit used by carrying out test borings with different bits.

Saw marks usually do not offer any possibility of identifying the saw used. In a few cases, some idea may be obtained by noting the degree of set and possibly also the number of teeth per inch of the saw used, but this can be done only if sawing was stopped before the wood was sawn through. In some cases it is possible to find, in the base of the saw cut, impressions of the teeth of the saw made when the saw was at rest for an instant before it was withdrawn. It is also possible to obtain from the base of the saw cut a measure of the width of cut and therefore of the approximate amount of set.

Hacksaw marks offer little possibility of identification. However, with blades with different numbers of teeth per inch, if the blade did not go through the piece of metal, it may be possible to examine the bottom of the cut and observe the impression of the teeth to obtain an idea of the number of teeth per inch. This may also be observed at the sides

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of the actual cut where the saw jumped and left shallow marks of the teeth in the surface of the metal, especially when first started.

Preserving a Tool

Once the tool has been found, care should be taken to preserve its evidentiary value. It should be carefully marked or tagged. If markings are made on the tool, they should not be placed in the area of the working surface. Similarly, minute items of trace evidence should be carefully preserved. The tool should be carefully packaged for transportation to the laboratory.

Tool marks made by cutting tools generally present little difficulty when the object cut is large enough to collect sufficient characteristics, such as the shackle of a padlock. Smaller items such as wire cable and multistrand wire show identifiable markings only in exceptional cases.

If the wire has plastic insulation as a covering, a physical match may be made by an examination of the extrusion markings on the cable as well as the microscopic jagged cut on the ends of the insulation. Generally striations on the fine wire will be insufficient.

Manufacturing marks such as casting, extruding, grinding, and so on are important when attempting to match items together physically. These markings and random breaks that occur when tools or other materials break or tear are important means of identification.

Impression or casting media must be chosen for each particular case, taking into consideration the type of material in which the mark is formed and its orientation, i.e., on the horizontal or vertical. Some impression materials such as plaster and plasticine have a tendency to shrink or expand after setting; they should not be used for casting. Dental impression creams have been found useful as casting materials. They generally come packaged in individual tubes, with one the catalyst and the other the setting agent, and are simply mixed and easy to apply. Other materials such as moulage, polysulfide rubber-based material, and silicone rubber are also useful.

A retaining wall should be built around the impression. Modeling clay or putty may be used for this purpose. The casting material should be thoroughly mixed according to the manufacturer's instructions and applied to the impression by means of a spatula. A tag with string attached may be used for identification purposes. The string may be inserted just below the surface of the casting material.

Fragments of Tools

At crime scenes where doors, windows, or locked drawers show signs of forcible entry, the investigating officer must remember to examine the floor immediately adjacent to the point of entry carefully before examining the actual tool marks. It is not uncommon for burglary tools to break during forced entry; therefore, large or small fragments of the tool may be found at the scene and prove to be very valuable as evidence. Broken pieces of a tool might also be found inside a lock on which picking or prying has been attempted.

In many cases it is possible to establish that such broken fragments originally were parts of tools found in the possession of a suspect. The physical matching of two or more pieces that originally were one piece — a so-called "fracture match" — is a most convincing and easily demonstrable type of proof against an offender.

The converse situation should also be kept in mind. A broken tool left by the burglar at the crime scene can be matched with fragments of that tool that may be found in the

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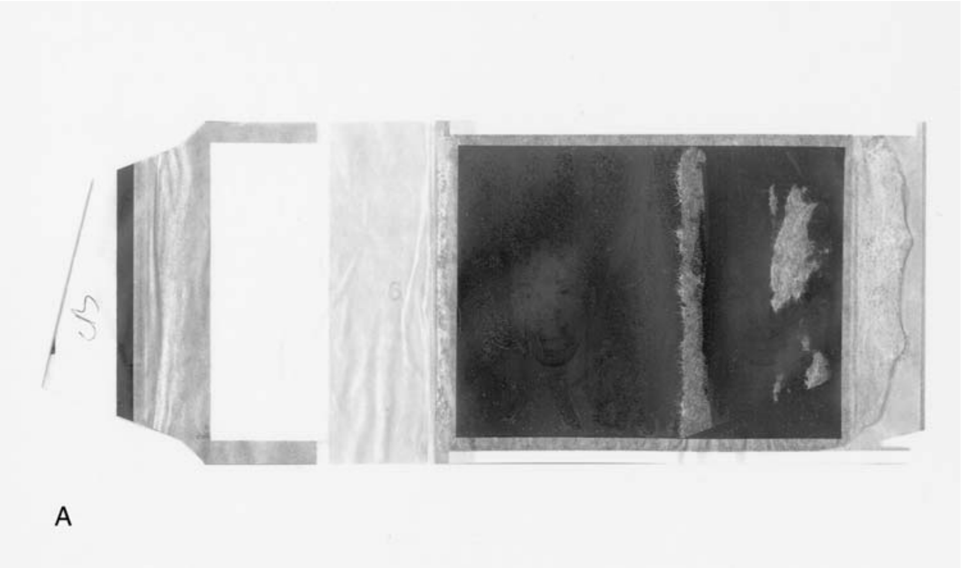

Figure 9.21 (A color version of this figure follows page 256.) A robber had his passport photo taken in a store and later returned and held up the proprietor. When the police came, the victim reported that he recognized the perpetrator as the person who earlier came in for his passport photo. The victim gave the Polaroid negative (A), which had a faint image of the suspect, to the police investigator. The photo lab was able to develop a poor-quality, but recognizable photograph (B). The photo was made into a drawing (C) and subsequently into a wanted poster. *(Los Angeles County Sheriff's Department.)*

suspect's clothing, home, or place of business. Pieces may also have been left at the scene of another burglary.

The search for such tool fragments is best done with a flashlight, the beam of which is directed over the search area at a very low angle. When the light strikes a metallic fragment it will give off bright reflections that make the particles easy to find. Any suspected fragment should be recovered and placed in a vial, envelope, or pillbox that can be labeled as to the time and place of recovery.

A magnet can also be used in searching for tool fragments. If a deliberate effort to look for such pieces of broken tools is not made, there is the risk of trampling them into the ground, embedding them in the officer's shoes, or kicking them aside while engaging in other routines of crime scene search.

Typed Documents

Marks from typewriters and check protectors are a special class of tool marks. As with other tool markings, these impressions may show specific and unique characteristics that may aid in the identification of a class or specific model of the instrument used.

Documents found at a crime scene may be typed or have some typing present. The investigator would like to determine the make, model, and specific typewriter or instrument used. In some instances this is possible; however, with the use of electric typewriters and interchangeable type balls, this may be difficult.

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Figure 9.21 (continued)

The best results are obtained in instances in which the suspect typewriter has a functional defect or a damaged typeface. With electric typewriters, factors such as keystroke pressure may not be a factor in identification.

It is preferable to bring the suspect typewriter to the questioned document examiner for comparison with the typewritten material in question. If this is not possible, the investigator should obtain ample specimens at the scene. These specimens should include several exemplars of all typefaces, both upper and lower case, and several prepared portions of the text copied from the document. The investigator's initials, date, and make, model, serial number, and location of the machine must properly identify these exemplars. If the location is in an office, it should be thoroughly searched (including wastepaper baskets)

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(C)

Figure 9.21 (continued)

for discarded typewriter ribbons and interchangeable type balls. Care must be taken when handling typewriters not to inflict additional damage on a machine.

Check protectors are used by financial institutions and many businesses. They are frequently used to imprint the amount in stolen or forged checks and money orders. Often checks are taken in burglaries and imprinted on machines located in the offices of the victim prior to the suspect's leaving the scene.

Generally, the make of the machine can be determined without too much difficulty by an experienced document examiner. However, the machine should be taken to the examiner for inspection and comparison with impressions on the questioned document. If the machine cannot be moved, extensive exemplars must be made in the field. Several

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exemplars of the questioned amounts should be prepared, preferably on specimen checks or money orders similar to the questioned documents. Additionally, specimens of all numerals and characters on the check protector should also be prepared on plain sheets of paper. All of these exemplars must contain proper identification, including the investigator's initials, the date, and the machine's make, model, and serial number.

Impression evidence is often encountered at crime scenes. Submitting that evidence to the laboratory along with the suspected tool frequently results in an identification.

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Firearms Examination

10

Crimes involving the use of firearms represent a significant area of police investigation. Firearms evidence may be present in crimes such as murder, attempted murder, suicide, assault, and rape. A number of questions may be answered by means of the proper utilization of firearms evidence: What kind of weapon was used? Was the weapon in proper working order? How far away was the weapon fired? In what direction was the weapon fired? Did a specific weapon fire a bullet? Did a particular person fire the weapon? (See Figure 10.1.)

Because of the importance of reconstructing the circumstances of the crime and corroborating accounts of the crime by witnesses, suspects, and victims, firearms evidence is particularly important. This chapter deals with the major areas of firearms examination as they relate to crimes of violence.

The field of firearms identification is sometimes improperly referred to as forensic ballistics or simply ballistics. This is an improper use of terminology. "Ballistics" generally refers to the trajectory taken by a projectile and assumes an understanding of physics. Firearms identification, on the other hand, refers to the study of firearms and includes the operation of firearms, cartridges, gunshot residue analysis, bullet and cartridge case comparisons, powder pattern determination, and the like.

Characteristics of Firearms

Today, there are literally thousands of types of firearms. They can be classed broadly into two groups: shoulder firearms such as rifles and shotguns, and handguns such as revolvers and pistols or automatic and semiautomatic pistols. (Bipod, tripod, and other exotic weapons are also sometimes encountered.) Of interest to law enforcement, handguns represent the firearm most used in crimes; shoulder arms are used less frequently. Obsolete weapons such as muskets, unusual firearms such as those disguised to appear as something other than a handgun, and homemade weapons such as "zip guns" are used with even less frequency (Figure 10.2).

Firearms may also be characterized by smoothbore and rifled weapons, the former used in shotguns and the latter in most other firearms. Rifling found in gun barrels is spiral grooves cut into the barrel that impart a twisting motion on the bullet as it leaves the barrel, resulting in a more stable trajectory. Muskets are another type of smoothbore (and sometimes partially rifled) firearm.

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Figure 10.1 Many date the beginnings of modern forensic firearms identification to the Saint Valentine's Day massacre on February 14, 1929 in Chicago. With the aid of a newly developed comparison microscope, Col. Calvin Goddard was able to identify the two Thompson submachine guns used in the infamous crime. Goddard's work led J. Edgar Hoover to persuade him to found the Scientific Crime Detection Laboratory at Northwestern University. *(Chicago Police Department.)*

Firearms may be single shot, revolver, automatic, and semiautomatic. The single shot firearm is loaded manually, fired, and unloaded manually. The revolver differs from the single shot pistol in that it has a rotating cylinder holding from 4 to 24 cartridges. Each time a cartridge is fired, the cylinder revolves by means of cocking the hammer or pulling the trigger, then placing the cartridge into position to be fired. The automatic firearm generally found in military weapons is a repeating type. Cartridges are fired in succession as long as the trigger is pressed. The semiautomatic pistol (often improperly referred to as an "automatic") functions similarly to the automatic, but fires only one shot each time the trigger is pulled.

In single shot- and revolver-type firearms, the cartridge casing generally remains in the weapon after firing, although single shot weapons have been made that eject cases automatically. With automatic and semiautomatic firearms, the cartridge case is ejected from the weapon automatically.

Shotguns differ in two major ways from other firearms: shotgun barrels are not rifled but are smoothbore and fire a different type of ammunition consisting of many lead pellets, rifled slugs, or shot. Shotguns are of the single- and double-barreled break action for reloading, pump action, semiautomatic, or bolt action types.

The caliber designation of a firearm, a somewhat complicated topic, is a measure of the bore of the barrel and is measured in 1/100 or 1/1000 of an inch or in millimeters.

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Figure 10.2 An example of a homemade firearm. *(Los Angeles County Sheriff's Department.)*

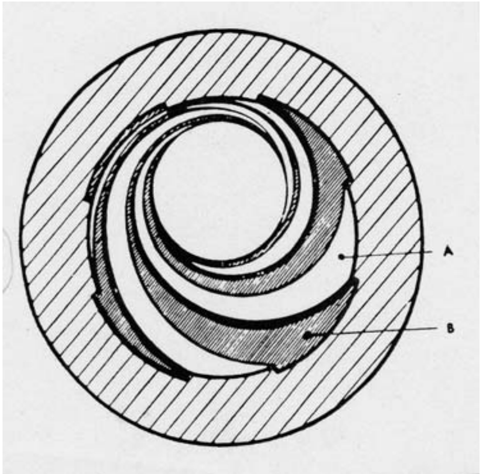

Figure 10.3 The appearance of the barrel of a weapon with a right-hand twist: (A) land; (B) groove.

The caliber designation is only an *approximation* of the bore diameter and usually somewhat closer to the groove diameter. For example, a .45-caliber semiautomatic has a bore diameter of approximately .45 inch. (The actual bore diameter is .444 inch and the groove diameter is .451 inch.). Shotgun bores are measured in gauges; the smaller the number is, the larger the diameter. Thus, a 12-gauge shotgun has a larger diameter bore than a 20-gauge shotgun. The term *gauge* was originally the number of lead balls of that size weighing 1 pound. This system does not hold for the .400 "gauge," which is in actuality a caliber.

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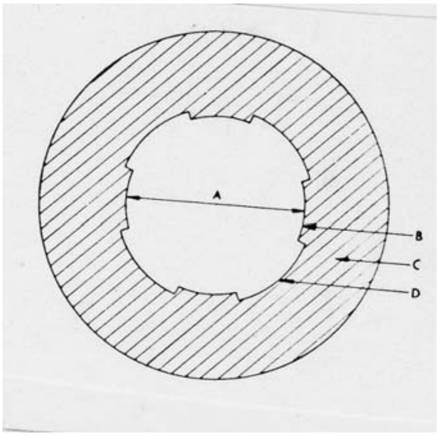

Figure 10.4 The caliber of a rifled weapon is generally determined from the diameter of the bore, measured between two opposite lands. However, there are exceptions to this rule: (A) caliber, (B) land, (C) barrel, and (D) groove.

Ammunition

Small arms cartridges or rounds are of two general types: *rim fire* and *center fire*. Rim fire ammunition is almost exclusively .22-caliber, while larger calibers are center fire.

Some older firearms, other than .22-caliber, did use rim fire ammunition. The terms *rim* and *center* refer to the position of the primer located in the base of the cartridge. In a rim fired round, the primer is in the rim in an area around the circumference of the base while center fired rounds have the primer in the center. The primer is a small shock-sensitive explosive charge in the base of the round used to set off the propellant powder when struck by the firing pin.

The bullet is the projectile fired from the weapon. Bullets are generally a lead alloy and jacketed with a harder metal such as copper or brass or nonjacketed. The purpose of the jacket is to keep the bullet intact and from breaking up when it strikes a target, to prevent damage while in the weapon, and to control expansion.

Gunpowder or smokeless powder consists of tiny cylinders, balls, or discs of nitrocellulose or nitrocellulose and nitroglycerine in so-called double-based powder. When confined and ignited, the powder rapidly burns, giving off a large quantity of gas. The expanding gas is the means by which the bullet is propelled through the barrel and out of the weapon. Black powder is also used in certain ammunition.

Firearms Evidence

When a weapon is fired, the firing pin strikes the base of the bullet detonating the primer, which in turn ignites the gunpowder. Expansion of gases forces the casing against the breech, which resists the rearward movement, and propels the bullet down the barrel. The bullet picks up the tiny imperfections of the bore as it passes through. The scratches or striations are caused by the imperfections in the lands and grooves placed in the barrel at the time of manufacture and caused through use of the weapon. Characteristic markings

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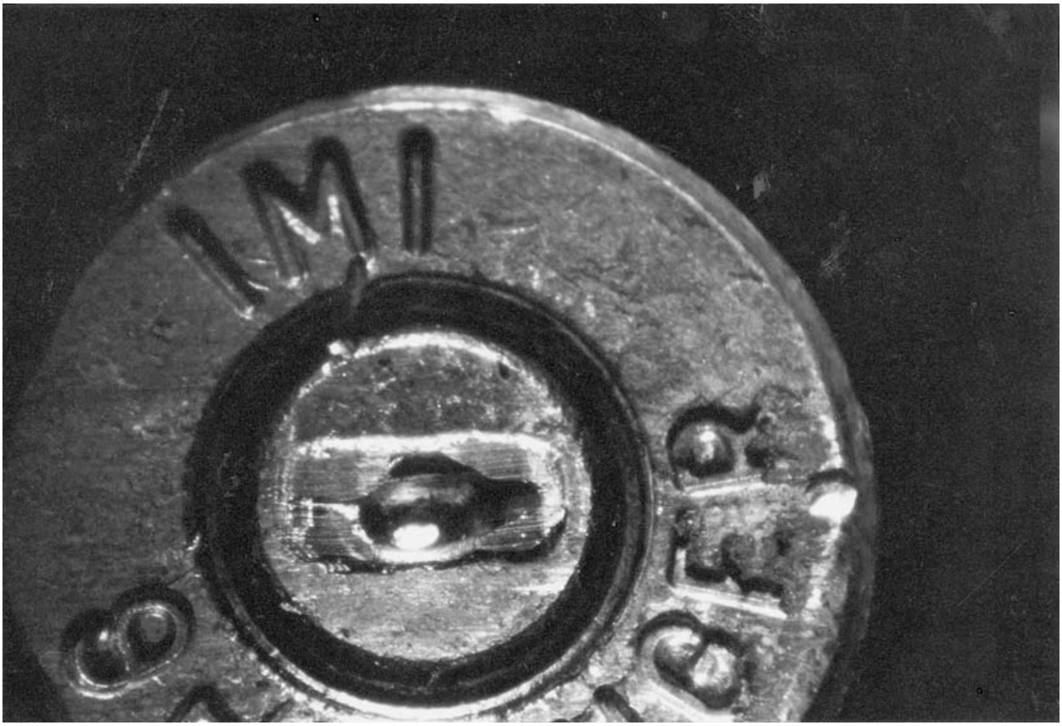

Figure 10.5 Determination of the make of pistol: cartridge case fired in the Austrian Glock 9-mm pistol; the rectangular firing pin hole is distinctive. *(Los Angeles County Sheriff's Department.)*

from the mechanical action of loading, chambering, and firing the round, as well as from extracting and ejecting the casing, will be present on the bullet, cartridge casing, and cartridge base. If compared against rounds fired from the same weapon, these marks will show similarities that the firearms identification expert can use to determine if the rounds were fired from the same gun.

Beyond determining that two rounds were fired from the same weapon, a great deal of other information can be developed from evidence associated with firearms. The presence of cartridge cases may indicate an automatic, semiautomatic, bolt-action or slide-action firearm, or a single-shot firearm when more than one round was fired. The relative location of the cases to the shooter may sometimes suggest the type of weapon fired or that a revolver was emptied at the scene.

Bullets and even fragments of bullets may be used to determine the type of weapon used from the size and weight of the projectile and an examination of the striations on the outside surface. For example, the number, direction of twist, and measurements of land and groove markings can be useful in determining the type, make, model, and caliber of firearm. Examination of the area that the bullet struck will yield information about the path and distance from which the weapon was fired. This is also possible with shot fired from a shotgun.

Tests on the shooter's hands can be made to determine if a weapon was recently fired. Finally, if the firearm is recovered, it can be tested to determine if it is in proper working order and if it could have been accidentally discharged. The owner of the firearm can possibly be determined by serial number examination.

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Figure 10.6 Weapons are test fired in a bullet recovery tank (A). The firearms identification expert makes use of a comparison microscope to compare bullets and cartridge cases (B). *(Los Angeles County Sheriff's Department.)*

Gunshot Residue Analysis

When the firing pin strikes the base of a cartridge, the shock causes the primer to detonate, in turn causing the ignition of the main gunpowder charge. The chemical reaction thus started causes a rapid expansion of gases, which propels the bullet out of the barrel of the gun. The by-products of the reaction are burned and unburned powder and the components of the primer mixture.

Primers use shock-sensitive compounds containing such materials as lead, barium, and antimony. Barium, antimony, and/or lead on a shooter's hands indicate that a gun was recently fired. Recently, some ammunition manufacturers have begun to market non-lead-based primers and bullets to limit the lead exposure of shooting enthusiasts (Figure 10.8).

Upon discharging a weapon, microscopic particles of gunshot residue (GSR) are deposited on the hands of the shooter as an aerosol.[1] These particles adhere to the hands but are removed by washing, wringing, or placing hands in the pockets. Handcuffing a suspect behind the back will dislodge these particles. Studies show that GSR material will remain on a shooter's hands for up to 6 hours. The particles are in the highest concentration immediately after shooting and are gradually lost over time. Because of this time factor, GSR evidence must be collected as quickly as possible.

[1] GSR particles can also be detected on clothing, and even the area surrounding an automobile window in the case of a drive-by shooting. However, sample collection results in considerable extraneous debris.

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Figure 10.6 (continued)

Atomic absorption spectrophotometry (AA), scanning electron microscopy/energy dispersive x-ray analysis (SEM/EDX), and inductively coupled plasma spectroscopy (ICP) are the most widely used methods for testing for GSR. The procedure used by a laboratory determines the way in which the evidence is to be collected.

GSR evidence is collected in one of two ways: with cotton-tipped applicators and dilute nitric acid solution for AA and ICP analysis, or with aluminum stubs with double-sided cellophane tape for SEM. The chemical components of the primer present on the shooter's hands are the substances tested for in the GSR procedure. In general, barium, lead, and antimony are characteristic of most ammunition. Certain .22-caliber ammunition, e.g., that made by manufacturers other than the Federal Cartridge Company, contains only lead.

GSR evidence collection kits are available commercially and through local crime laboratories. In all cases, the person collecting the evidence should wear plastic gloves to prevent possible contamination of the evidence. Information concerning the subject's occupation and hobbies should be noted. This is important for interpretation of test results.

Obtaining GSR results is straightforward, but its interpretation is another matter. Negative GSR results (no GSR detected) do not conclusively mean that a subject did not

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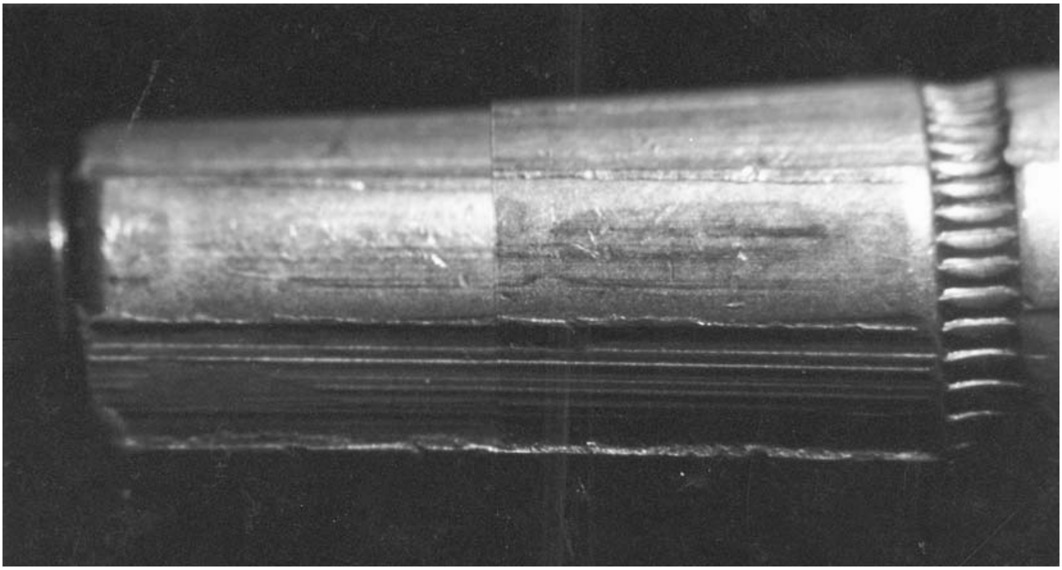

Figure 10.7 Two bullets pictured end to end under a bullet comparison microscope show characteristic markings imparted by the barrel onto the bullet's surface. The firearms examiner needing to determine whether two bullets were fired from the same weapon uses these markings. The horizontal band around the circumference is the cannelure. *(Los Angeles County Sheriff's Department.)*

fire a handgun. Similarly, positive GSR results do not prove someone fired a gun because a person could have handled a gun or been in close proximity to a gun that was fired.

A shooting suspect's hands should be protected until the test is given. Handcuffing behind the back is likely to remove GSR. Hands may be bagged loosely with paper bags but not in plastic bags, which cause perspiration and hence a cleansing effect. In the case of a deceased subject, the 6-hour time limit is flexible but the hands should be protected until such time as the evidence can be collected.

Because of the ambiguity in conclusions about whether an individual fired a weapon, a number of forensic laboratories have opted to discontinue this service.

Collecting Firearms Evidence

The crime scene in which a firearm was involved should be processed in much the same way as that discussed earlier in the text. In addition, a number of other considerations must be taken into account in these types of cases.

When sketching and measuring the crime scene, it is particularly important to carefully note and measure the location of all shell casings, bullet holes, bullets and bullet fragments, and shotgun shot patterns that are found. This information is vital to the reconstruction of the crime and can be used to verify statements by witnesses and suspects. Special care must be taken when walking through the location so that casings or bullets are not stepped on or inadvertently kicked (Figure 10.9).

If a weapon is found at the scene, it should not be moved until its location is noted through measurement, sketches, and photographs. The investigator should remember that

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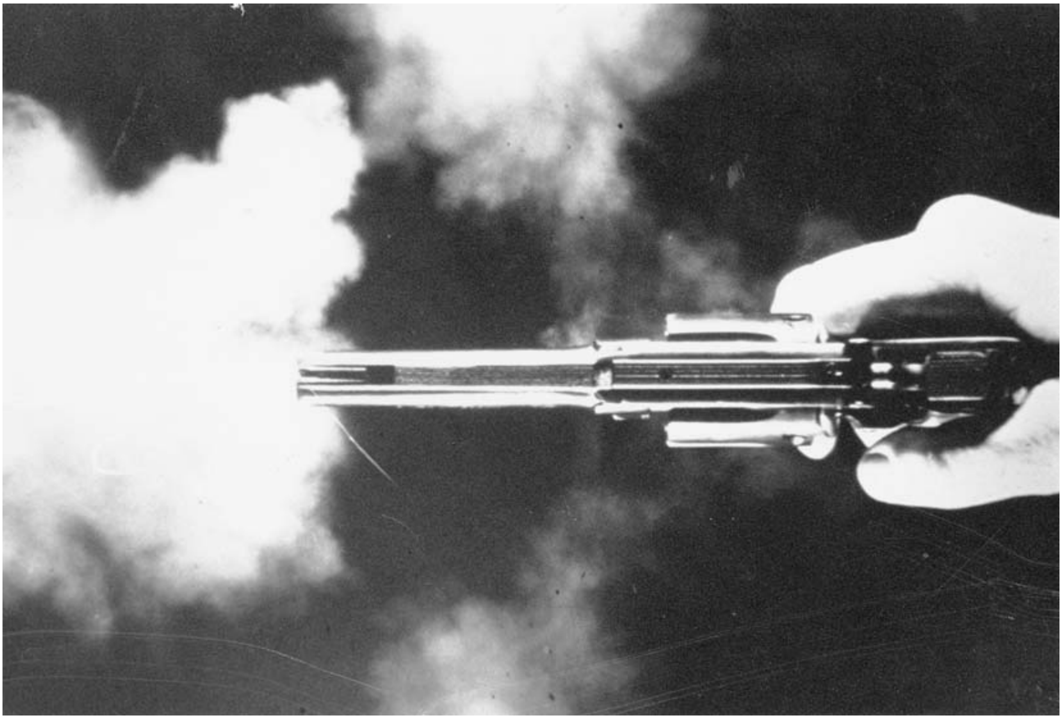

Figure 10.8 When a firearm is discharged, gases from the detonation of the primer and burning of gunpowder escape from the barrel and cylinder. These gases, along with burned and unburned particles of gunpowder and primer, can be used to test whether a person recently fired a weapon or to estimate the distance to a target. *(Los Angeles County Sheriff's Department.)*

fingerprints might be present, so when the weapon is moved, it must be handled in a way that will not destroy them. The floor below the weapon should be examined for a depression or other marks that would indicate that it was dropped from some height or fell from the shooter's hands. Traces of wood, fibers, paint, building material, blood, and hair should be looked for on the weapon and carefully preserved if found.

If the dead person is holding the weapon, it is important to note the exact grip and position of the weapon in the hand. The murderer may have placed it there. In such a case, the way in which a weapon is held in relation to the injuries on the body is decisive as to whether the dead person could have produced the injuries. In the case of an automatic pistol, the recoil of the slide may have caused a surface graze in the region of the thumb or the web of the hand, and the presence of such an injury is suggestive that the dead person had fired a shot with an automatic pistol. A closer examination of the hand of the dead person may show marks of powder, especially if a revolver had been used. From these marks, the investigator may deduce that both hands were in the vicinity of the muzzle blast or the gap of the revolver. One hand may have been used as a guide while the other pressed the trigger, or both hands may have been held up in defense.

In the case of long-barreled guns, rifles, and shotguns, special attention should be given to the possibility of the dead person's having fired a suicide shot with the weapon. Special arrangements such as string, belts, sticks, and the like may have been used, and these in turn may have left marks in the form of fibers, dirt, soot, or the like on the trigger

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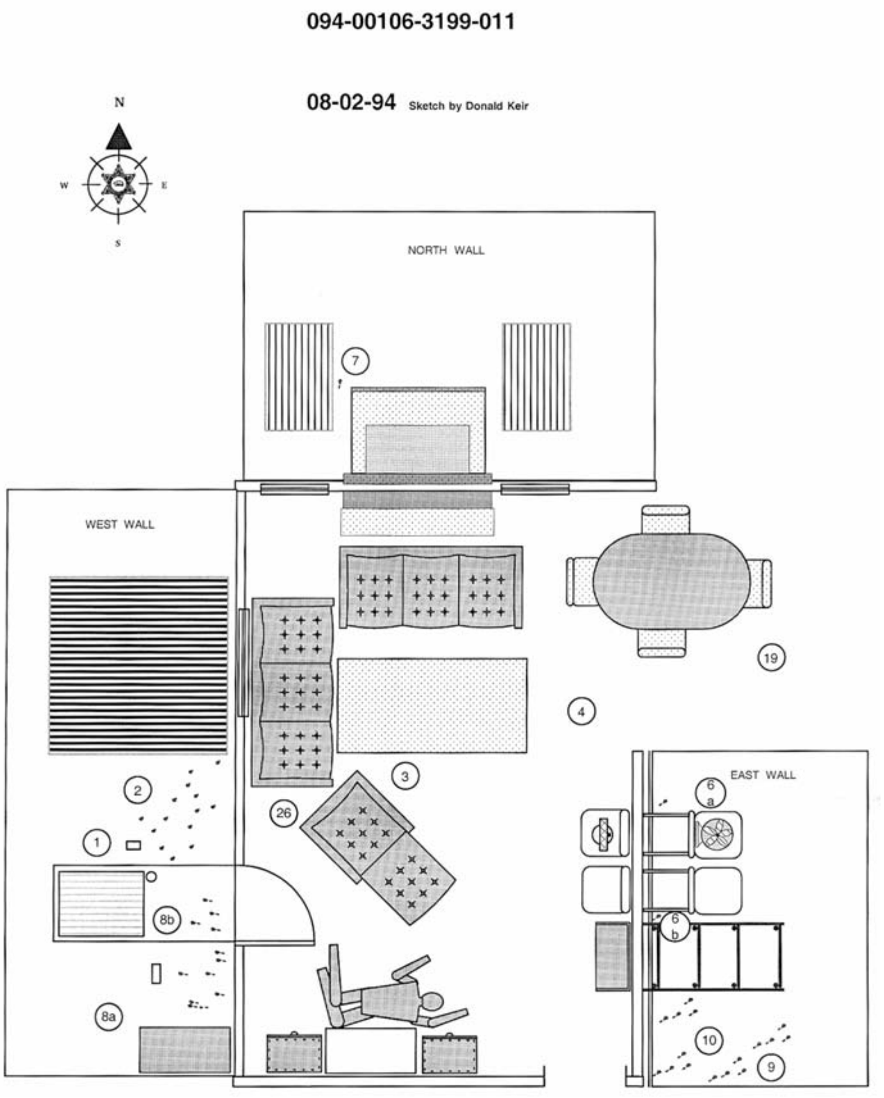

Figure 10.9 An example of a crime scene diagram used to depict the approximate trajectories in a shooting. *(Los Angeles County Sheriff's Department.)*

or trigger guard. One shoe may have been removed in order that the trigger was depressed with a toe.

The position of cartridges, cartridge cases, and bullets is just as important as that of weapons. From their position it may be possible to deduce the position of firing, direction of the shot, and in certain cases the path of the bullet. If a bullet has penetrated a tree, piece of furniture, or wall, the shot track gives information regarding the direction of the shot and often also the path of the bullet. There is a much better opportunity of determining the exact course of a bullet when it has passed through a fixed object such as a windowpane, and then struck a wall. With the aid of the path of the bullet and of shot wounds on the dead person, it is possible to determine the deceased's position when shot. In calculating the distance of the shot, the depth to which a bullet has penetrated, e.g., a

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wall, may be significant. The penetrating power is dependent on the distance of the shot, but allowance must also be made for the loss of energy in passing through an object, such as a body. A more accurate determination of distance can be made with the aid of gunshot injuries on the clothes and body of the dead person.

The position of a bullet found at the scene of a crime should be recorded in the same way as for weapons; bullets should be collected separately and packed so that there can be no confusion. If two or more weapons have been used, the bullets should not get mixed up so that, at a later date, the place where each one was found can be fixed exactly. Great care should also be taken in collecting and packing bullets so that the microscopic marks from the barrel of the weapon are not injured or destroyed. For this reason, a bullet that has penetrated or lodged in a wall should *not* be probed for and dug out by means of a knife, ice pick, or chisel. Instead, a portion of the wall surrounding the bullet should be carefully removed in one piece and the bullet recovered by breaking away the supporting material. Because it may become important to ascertain other objects that came in contact with the projectile, persons who have touched blood must not handle it, nor should adhering dirt be removed until a microscopic study is possible. Care should be exercised that the investigator's marking of the bullet does not destroy this trace evidence (Figure 10.11).

The same considerations with respect to fixing the position and taking possession of weapons and bullets apply to cartridges and cartridge cases found at the scene of a crime. The position of a cartridge that has misfired or of a cartridge case that has been ejected from an automatic pistol may give an indication of the type of automatic pistol used and form a valuable supplement to the determination of the make of pistol from marks left by the weapon on the bullet and case. Many automatic pistols differ with respect to the ejection of the cases; some throw them out to the left, some to the right, and some straight up. The case is thrown out with a force that varies for different types of pistols, but is generally considerable, so that it may rebound against furniture, walls, wall coverings, and so on and change direction. The position may give some indication of the type of weapon; however, there is often variation from weapon to weapon. If a cartridge case has not bounced off any object and has moreover fallen onto an underlayer that prevents it from rolling (carpet, lawn, etc.), then its position gives a direct indication of the type of weapon and place or direction of firing. If three of these factors (position of cartridge case, type of automatic pistol, place of firing, direction of shooting) are known, then the fourth can be determined. Outdoors, however, it is necessary to take into account the direction and strength of the wind; in all cases the inclination of the ground must be considered.

The position of wads and overshot wads (the latter are no longer used in shot shells), which often remain relatively undamaged, from shotgun cartridges and muzzle-loading weapons, also gives information regarding the direction of shooting. These can generally be found about 5 to 8 yards or more from the place of firing in the approximate direction of fire, but it is necessary to take into consideration the direction and strength of the wind. The overshot card placed in front of the charge of shot shows, if found, a manufacturing mark and also the size of shot given by a number or letters.

As mentioned previously, weapons and also cartridge cases, bullets, shot, and wads may carry marks from the victim or the criminal that may aid in solving the crime. It should always be remembered that latent fingerprints and fingerprints in blood, grease, or the like may be found on weapons and must be protected.

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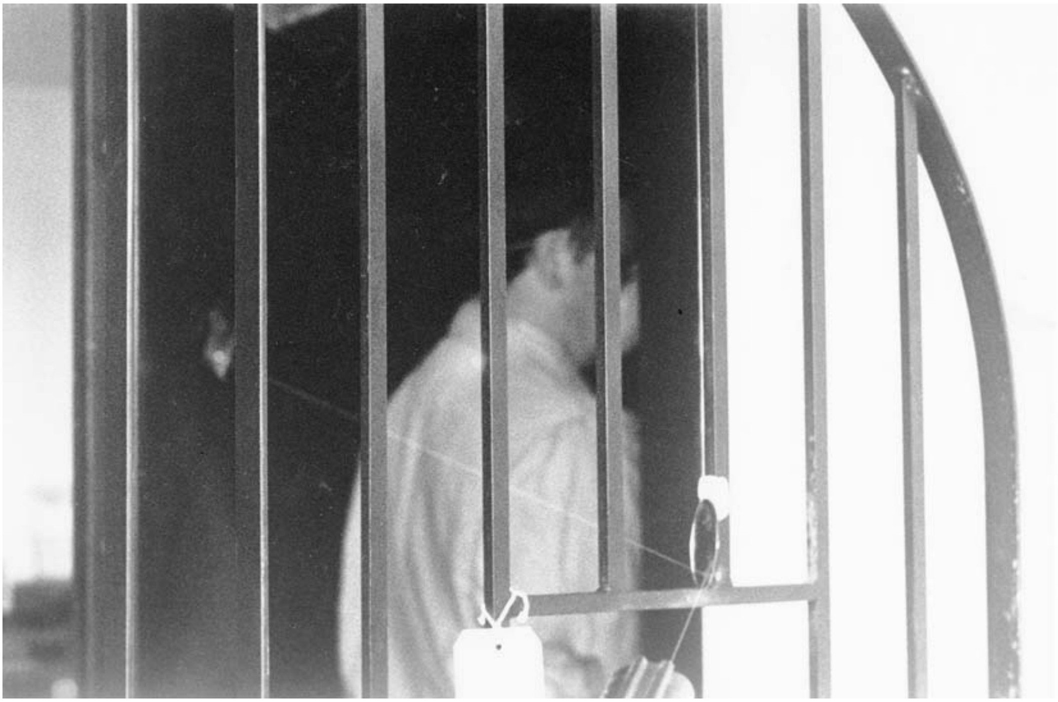

Figure 10.10 The subject entered the Casino Bar in the early morning hours, then robbed and shot the sole occupant of the bar, a cashier who was working in the cashier's cage. The victim was shot in the back; a large portion of the lead slug was removed from his body during an autopsy. Two ricochet marks were found at the crime scene. When the suspect was apprehended, a 20-gauge Ithaca shotgun along with several 20-gauge "Slugger" shotgun shells of Remington–Peters manufacture was found in his possession. To reconstruct the crime scene, a portable laser was placed outside the cashier's cage and the beam was directed at the area of the bullet's first deflection on the cage. A mirror was placed in this area. A beam deflecting from the mirror traveled to the steel door of the vault and hit a ricochet mark on the door. Another small mirror was placed in this area on the vault door, and the laser beam deflected onto the right shoulder of a model standing in the doorway, the same area where the lethal wound was located on the victim's body. *(South Dakota Attorney General's Office, State Forensic Laboratory.)*

A weapon that has been used in a case of murder, suicide, or assault may contain marks from the victim in the form of blood, hair, fragments of textiles, cloth fibers, and so on. Such clues may appear to be of little value, but if it is necessary to prove that the weapon was actually used in a particular case, these clues are then of the greatest value. Loose hairs, dried blood, fibers, and the like should be placed into a test tube and the weapon taken and packed in such a way that fingerprints or other clues are not destroyed. A container that suspends the weapon with the minimum of bearing surfaces is preferred. These can be constructed from pegboard, heavy cardboard, or similar material. Wrapping an object in cotton, gauze, or tissue will more than likely dislodge trace evidence. If fingerprints and bloodstains are found on a weapon, the latter might be destroyed if the whole of the weapon is dusted with fingerprint powder. It is therefore convenient, first, to make sure that such traces of blood, hair, and the like are not on or near the fingerprints. The presence of latent fingerprints on metal surfaces can be observed easily under proper lighting (Figure 10.12).

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Figure 10.11 An evidence bullet carelessly marked in the region of the rifling impression. Valuable evidence was thereby destroyed. Bullets should be marked for identification on the base, and cartridge cases on the inside, near the mouth. However, a preferable procedure is to place the bullet in a container and label the package instead of the bullet. *(Los Angeles County Sheriff's Department.)*

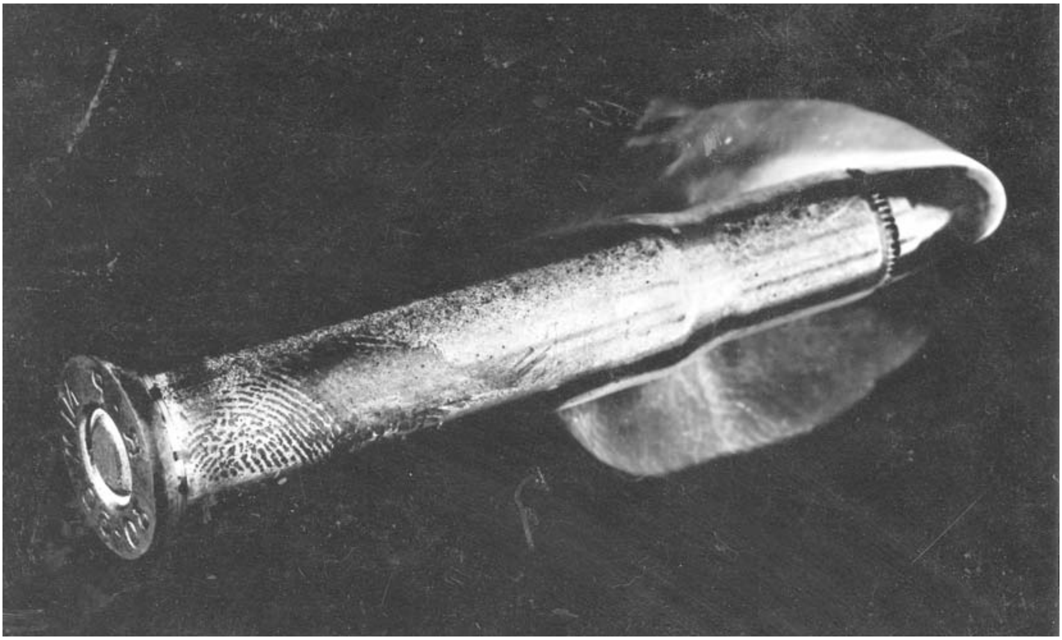

Figure 10.12 Investigators should keep in mind the possibility of latent fingerprints on bullets. *(Alaska Department of Public Safety, Scientific Crime Detection Laboratory.)*

Contamination in the form of oil, cement, paint, or similar material may also be significant in determining the way in which a criminal acquired a weapon or may give an indication of where a weapon was kept previously. It may possibly have been taken from the criminal's place of work or in an earlier burglary in which the criminal was less careful and left fingerprints or other clues that can be used as incriminating evidence.

If the weapon has been concealed at the scene of the crime or in the vicinity, or taken away by the criminal, it is important to know the type of weapon for which one is searching.

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The only means of determining this is from a study of the injuries on the victim or by removal of the bullet at autopsy. In practice, it is often difficult to draw the correct conclusions from the appearance of the wounds because they are affected by the elasticity of the skin, underlying bones and muscles, angle of application, and other such factors. In these types of cases, however, the pathologist can give valuable assistance.

Handling of Firearms

In lifting firearms, great care must be taken not to destroy evidence. The best way to lift a pistol or revolver is to hold it with two fingers on the checkered part of the butt, or possibly by the ring on the butt. Shotguns may conveniently be held around the checkered part of the neck of the butt; if necessary the weapon can be lifted by a steady grip with the fingers on the trigger guard. It is undesirable to lift a weapon by placing a stick or similar object in the trigger guard, even with a light weapon such as a revolver or pistol, because the weapon may be cocked and a shot might be fired if the trigger happens to be touched. It should be taken as a general rule never to lift a weapon found at the scene of a crime before first making sure that no one is in the direction in which the muzzle is pointing; of course one should not risk being hit if the weapon fires while being lifted. The weapon may actually be cocked so that even the slightest movement could cause a shot to be fired.

The procedure for picking up a gun by putting a pencil or stick in the barrel is absolutely wrong. This may destroy valuable clues in the barrel that might possibly have been of use in elucidating the case. In a contact shot (i.e., when the muzzle is in contact with a body), which is common with suicide, it often happens that blood, grease, fragments of fabric, and textile fibers are blown into the barrel of the gun by the violence of gas pressure and the splash of tissue and blood in all directions. With a contact shot it has sometimes happened that these particles have been recovered in the magazine of an automatic pistol.

A layer of dust, spider webs, or loose rust particles found in the bore may indicate that no shot has been fired from a weapon for some time. The absence of a powder deposit or the presence of grease in the bore may also indicate that the weapon has not been used, while an examination of the powder layer in the bore may show that the fired cartridge was loaded with black powder or with smokeless powder. It is difficult to decide from the appearance of the powder deposit how much time has elapsed since the last shot was fired from a weapon. Therefore, if the bore of a weapon is to be examined for any such clues, introducing any object into it will interfere with its examination or make it impossible. For the same reason, cotton or the like must not be put in the muzzle during transport of the weapon or when it is sent to an expert. In order to protect any deposit in the bore, a twist of paper, rubber cap, or muzzle protector can be placed over the muzzle. The layer of dust in the bore is always thickest near the muzzle and decreases in thickness progressively toward the breech, assuming that it has resulted from a long period of storage. The confirmation of such a distribution of the deposit nearest the muzzle is therefore of great importance. Under no circumstances should an investigating officer put the weapon into his own pocket for safekeeping. After only brief contact with pocket dust, the gun will appear to have been unfired for some time.

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Case of Homicide

A man was found dead in his house, with two shot wounds in his head. A revolver, which belonged to him, lay a little to the right of the body. The revolver was not loaded and did not contain any empty cartridge cases. An investigation of the barrel showed that the latter was contaminated with dust to such an extent that it could hardly have accumulated during the 2 days that were supposed to have elapsed after the shooting. Further investigation revealed that the man had been shot with a revolver of the same caliber and type as his own and that the murderer had placed the latter near the body to give the appearance of suicide.

After the weapon has been picked up, any loose objects or particles such as hair, fibers, dried blood, brain substance, and the like that might fall off in transport are removed and kept. With a near shot against a hair-covered part of the body, sometimes strands of hair can be found held fast between the slide and barrel of an automatic pistol. Any traces on the weapon in the form of fibers of wood, paint, cement, or the like, which might indicate that the weapon had fallen on the floor, should also be collected while at the scene of the crime.

When a weapon is taken into possession, it should be subjected to a preliminary examination for fingerprints. Fingerprint impressions in grease or blood can easily be seen. Latent fingerprints on metal surfaces can be made evident by breathing lightly on the object. If fingerprints and bloodstains, fibers, and so on are found on the weapon, and all must be preserved, it is advised to make sure first of marks not in the immediate neighborhood of the fingerprints because, otherwise, they could easily be destroyed by the fingerprint powder. Warning: if the weapon is found outdoors or in an unheated room in cold weather and fingerprint impressions in grease are on it, then the weapon should not be brought into a warm room because the grease can be softened or melted and the prints lost. If latent fingerprints are to be developed by powder, care must be taken to keep the powder from entering the barrel. Likewise, when a revolver is processed by powder dusting, the front of the cylinder must be protected so that the mouth of each chamber can be examined for flaring.

Everything found in the first examination of the weapon should be written down accurately; any objects or particles removed from it should be placed in a test tube or envelope labeled accurately with the exact place of finding. For the sake of identification, any maker's or type markings should also be indicated, as well as the caliber marking and serial number. The investigator's initials should be inscribed on some major part of the weapon such as the barrel or frame, or the weapon may be tagged. It is most important to write down the condition of the weapon when found, if the safety is on or not, which can be seen from the position of the safety catch (on revolvers, there is generally no visible safety device), and whether the weapon is cocked and loaded. With some automatic pistols, the latter cannot be observed by a superficial glance, but where it is shown by, for example, an indicating pin, it should be noted. In the most common types of weapon this condition can easily be confirmed from the position of the rear part of the bolt. It should also be noted whether the bolt (breech block or slide) is closed, partly open, or fully open. A cartridge case jammed in the ejection port should be noted, together with a statement of

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the exact position of the cartridge, whether the base or neck of the case is turned outward, etc., and also whether the magazine is firm or loose (not pushed right home).

After the exterior of the weapon has been processed for fingerprints, the gun may be unloaded and rendered safe before it is shipped to a laboratory. With an automatic pistol the magazine is loosened, after which the slide is moved to remove any cartridge in the chamber. In doing this, it should be remembered that fingerprints might be found in grease on the cartridge in the chamber and on the sides of the magazine, which should therefore be examined first before any further handling. The weapon should not be considered unloaded until an inspection is made by looking into the chamber through the port of the gun. A broken extractor, jammed cartridge, or other factor may cause a cartridge to remain in the chamber. It is a poor practice to assume that a weapon is unloaded simply because a cartridge was not ejected. The cartridge is placed into an envelope or container with a label attached; a label can also be tied on by a thread around the groove of the cartridge. Any cartridges in the magazine should not be "stripped" if the weapon is to be sent to an expert for examination. Cartridges may carry fingerprints and also marks from the guiding surfaces of the magazine, and it may be of significance to confirm them (e.g., whether the cartridges have been charged into the magazine several times). Furthermore, the order of the cartridges in a magazine may be important in certain cases and should always be noted.

In the case of a revolver, nothing should be done with the cartridges in the cylinder if the weapon is to be examined further. The exact position of the cylinder at the moment when the weapon is found is significant from many points of view and should be noted, e.g., the position of the fired cartridge in relation to the hammer. The position of the cylinder can be marked if desired with a pencil or chalk mark, provided that this does not destroy other clues. The cylinder should not be "rolled" because then irrelevant marks from the recoil plate or firing pin could be formed on the bases of the fired cases and the cartridges.

In the case of weapons of single shot or repeating types, nothing should be done with the bolt unless the weapon is cocked or has the empty case in the chamber. If, however, the hammer is cocked, an unfired cartridge may be in the chamber and should be removed to prevent any accident. The cartridge is taken out and labeled as described earlier. Semi- or fully automatic weapons generally have a cartridge in the chamber unless the bolt is in the backward position, so the slide should be moved while making sure that no fresh cartridge is introduced into the chamber. In order to prevent this, a detachable magazine is removed from the weapon; in the case of a fixed magazine, the uppermost cartridges are held back with a piece of wood or some other object that will not injure the cartridges or deposit any fresh marks on them.

All the precautions taken with a firearm must be put down accurately in the report. Later, possibly, the investigating police officer may be required to describe these precautions in connection with legal proceedings. What may appear to be of subordinate importance during the investigation of the crime may later be especially significant. In connection with all firearms, when a weapon is to be sent to an expert for examination, the only clues that need to be preserved are those that might be destroyed in transit; the only measures taken are those that cannot be omitted without risk of accident or that are essential in assisting the search for the criminal. Many traces on the weapon or significant facts in connection with the mechanism can be of such a character that special instruments or specially trained personnel are necessary to deal with them properly. Perhaps marks of colored lacquer from the sealing around the primer are on the breech face or recoil plate; a chemical examination may be required to confirm whether this could have come from a specific fired cartridge.

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Figure 10.13 This figure illustrates a head stamp impression in the grease on a breechblock. *(Contra Costa County Sheriff's Department, Criminalistics Laboratory, Martinez, California.)*

Even in the bore, lacquer pigments from the sealing between the bullet and case or metallic particles from the jacket of the bullet may be found. In grease and dirt on the breech face an impression of the markings may also be on the base of the cartridge case; special arrangements will be required for photographing this impression (Figure 10.13).

As mentioned earlier, from the point of view of identification, any marks indicating maker, type, and caliber should be recorded, together with the serial number. With many weapons, in particular certain pistols and revolvers, such markings are often lacking. The butt plates, however, are usually marked with the maker's or seller's initials, which can be a good guide.

Many weapons also carry *proof marks.* A number of European countries strictly regulate the manufacture of firearms and require a special mark to be stamped on the weapon's barrel to indicate that it has been tested and found safe. Proof marks are also found on some American-made weapons sold in foreign countries. In cases of inexpensive firearms, the proof mark may be the only clue to the manufacturer of the weapon.

Occasionally, firearms are recovered from which serial numbers have been ground off for the purpose of concealing the ownership of the weapon. When numbers are stamped into the frame of the weapon, changes in the metal structure deep below the surface result. If the process that removed the stamp was not sufficiently deep, the serial numbers or markings can be restored. Depending upon the nature of the metal, a number of techniques are possible: chemical etching, electrochemical etching, and heating (Figure 10.14).

Cartridge Cases

If no cartridge cases are found at the scene of a shooting, it may be suspected that a revolver, single shot pistol, automatic pistol with cartridge case collector, rifle, or shotgun was used.

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Figure 10.14 Two revolvers were factory stamped with the same serial number. When one of the guns was submitted to the laboratory as part of a criminal investigation, a record check showed that the weapon belonged to an individual residing in northern California. The owner was contacted and advised that his revolver had been recovered. To the investigator's surprise, the owner reported that he had the gun in his possession. The firearms investigator obtained the second gun to photograph this unusual occurrence. *(Los Angeles County Sheriff's Department.)*

Theoretically, one might expect that criminals would attempt to guard themselves by picking up the cartridge cases thrown out by an auto loading weapon, but in practice, it is hardly ever done because it would waste time and the criminal would run more risk of being discovered, especially if the shooting was heard by persons in the vicinity.

In taking possession of cartridge cases one should not forget the possibility that significant clues may be found on them in the form of loose particles or fingerprints. These may be picked up by means of a clean matchstick or the like, introduced into the case, and then placed into an envelope marked with the place of finding. The internal diameter of a cartridge case corresponds at the neck with the diameter of the bullet. From the size, form, and appearance of a cartridge case, it is possible to obtain an indication of the type of weapon used.

Revolver cartridge cases are almost always fully cylindrical, with a rim but no extractor groove (a groove for the extractor running around the case with the rim). They may be made for rim fire (smooth base) or center fire (with primer cap). Many manufacturers make revolvers to take automatic pistol cartridges. Thus both Colt and Smith & Wesson

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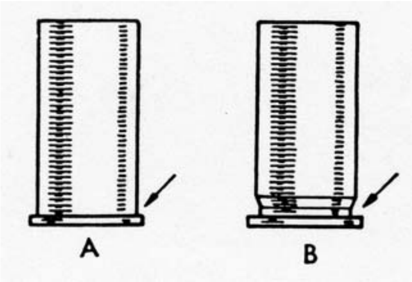

Figure 10.15 The difference between a revolver cartridge case (A) and a cartridge case intended for an automatic pistol (B). The former has no extractor groove.

make revolvers of .45 caliber so that automatic pistol cartridges of .45 caliber can be used in them. Similarly, automatic pistol cartridges of 7.65-mm can be fired in .32-caliber revolvers and automatic pistol cartridges of 6.35-mm can be fired in .25-caliber revolvers. Automatic pistol cartridges (with the exception of .45-rimless cartridges, 9-mm Parabellum cartridges, and bottle-neck cartridges) have a rim that, although not much larger than the cylindrical surface of the cartridge, is quite sufficient to hold the cartridge fast in the chamber of a revolver cylinder when the internal diameter of the latter corresponds with the diameter of the cartridge. In many revolvers provided with one common extractor for all the cartridges, the rim also functions quite satisfactorily when pistol cartridges are used.

Revolver cartridges of .320 caliber can also be fired in certain automatic pistols of 7.65-mm caliber. In some cases such pistols have also repeated normally and even ejected revolver cartridge cases, but the ejected cases are often ruptured and sometimes jam the pistol.

Smaller caliber projectiles can be fired in larger bore weapons with serious effect. An example of this is the ability of a .38-Special revolver to fire .32–20 cartridges. Desperate persons in need of ammunition wrap cartridges in paper to accommodate a larger chamber, reduce the diameter by filing, even perform the dangerous act of driving a cartridge into a chamber by means of a hammer. Only an expert can determine with reasonable certainty the type of gun that might have been used in a shooting by an examination of the fired bullets or cartridges. An investigator must be careful not to pass up a weapon because it does not *seem* to correspond to the ammunition at hand.

Caliber and manufacturer's marks generally are found on the base of the cartridge case and sometimes also the year of manufacture. Sometimes the maker's marks are in code consisting of letters and figures or of only letters or figures.

Fired cartridge cases are especially valuable for identification because they show marks from the weapon that in most cases make it possible to decide with certainty whether they were fired from a particular weapon or not. It is therefore of special importance in an outdoor shooting that all possible efforts be made to determine the location of the shooting so that any cartridge cases left behind can be found. The most valuable marks on cartridge cases are those made by the firing pin on the primer and by the breech face on the primer and base of the case, but the marks produced by the extractor, ejector, and the edge of the breech may also be important (Figure 10.16). Flaws or damage in the chamber may also show on the metal case and make identification of the weapon possible. If, when the criminal is found, he or she has already thrown away the weapon where it cannot be recovered (e.g., in water), it is important to attempt to find out whether the criminal or

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Figure 10.16 (A) Identification of a cartridge case of 7.65-mm caliber (.32 autos) with a suspect cartridge case (B). The microscopic details in the marks of the firing pin on the primer agree completely in the two cartridge cases. *(Los Angeles County Sheriff's Department.)*

some other person (e.g., the previous or legal owner) ever fired a test shot, and if so, where. It is possible that the cartridge case and the bullet may be found there. With cartridge cases it is not particularly important whether the test shot was fired a long time before. The part of the weapon that leaves marks on the case may not have altered even though there was a long interval of time between the test shot and the crime. It is different in the case of bullets because sometimes the bore of a weapon may undergo such changes in a comparatively short time that comparison of a bullet with a test shot fired previously is useless. The nature of the place where the weapon has been kept and the number of shots that have been fired with it are important factors.

From the marks made by the extractor, ejector, and edge of the breech of an automatic pistol on a cartridge case it is also possible to determine the make of automatic pistol from which the case was fired. Automatic pistols of different types and makes are often constructed differently with respect to the position of the extractor and ejector; this in turn affects the formation of the breech. The combination of these factors forms what is known as a system, that is, the characters mentioned allow classification of the type of construction of the pistol. If both cartridge case and bullet are available for determination of the make, the possibilities are increased because the number of land marks on the bullet, their width, and the angle of twist can also be characteristic of a type of weapon and, in any case, form a valuable contribution to the investigation.

Under no conditions should a cartridge case that is to be examined be tried in the chamber of a weapon; any marks made by the weapon on the case may be destroyed and other marks may be formed. It happens sometimes that at the scene of a crime in which a firearm has been used, a cartridge is found that has misfired and been thrown out by movement of the slide or bolt, or that has jammed between the breech-lock and the edge

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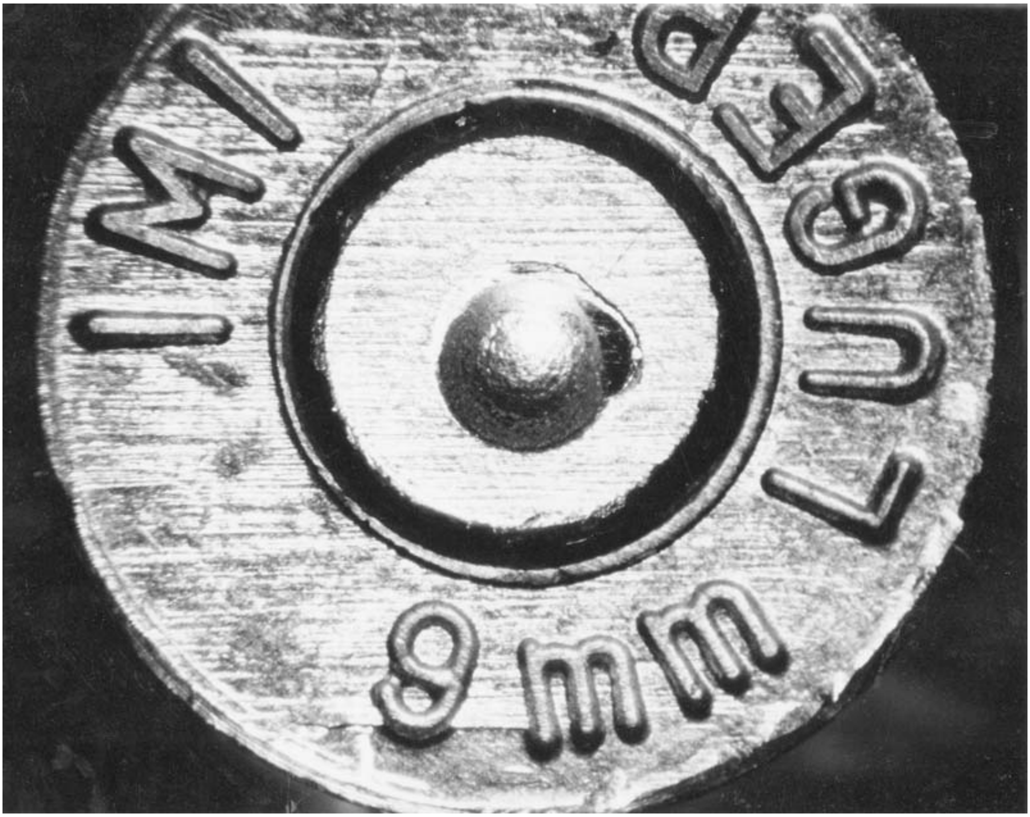

Figure 10.17 Firing pin drag showing movement of barrel during unlocking. *(Los Angeles County Sheriff's Department.)*

of the breech and been removed by hand. Even such an unfired cartridge may carry valuable marks that can make possible an identification or determination of the make of the weapon used (Figure 10.17).

Bullets

Bullets that penetrate hard objects are often severely mutilated, sometimes to a degree that the weapon from which they were fired cannot be identified. Therefore, every effort must be made to preserve what little remains of the rifling impression when a bullet is lodged in a wall, tree, or bone.

In the latter case, the method of removal, if at all, will depend on whether the shooting victim is dead. If the victim is dead, the principles for bone, tree, or wall are alike. No projectile should be pried from its position. Instead, the supporting material and the bullet should be cut out as one piece. Then the surrounding bone, plaster, or wood can be broken away carefully, leaving the projectile in the best possible condition, considering all circumstances. If the investigator wishes, the bullet as embedded in supporting material may be sent to the laboratory. Bullets removed by probing show ample evidence of the destructive effect of improper technique. Prior to removal, some careful testing will indicate the direction of the bullet's track.

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Marking Bullets

After removal, the bullet should be initialed on the base. No mark should be placed on the rifling impression or on areas of ricochet. If in doubt as to the proper area to mark, the investigator should place the bullet in an envelope, a plastic vial, or a small box, then seal and mark the container.

Bullets may be of different sizes and shapes and made in different ways. The most common types are entirely of lead, semijacketed, or fully jacketed; but there are also bullets with a hole in the point (hollow point), with the point covered with softer metal, lead bullets with a copper cone pressed into the point, and the like.

With fully jacketed (solid nose) bullets, the jacket encloses entirely the point of the bullet but is open at the rear end of it, exposing the lead core. With a semijacketed (soft nose) bullet, on the other hand, the jacket encloses the whole of the rear end of the bullet while the core is free at the point to a larger or smaller extent. The semijacketed bullet breaks up when it meets a bone or other hard part of the body, but if it passes merely through soft parts it may remain relatively undamaged. If it strikes the branch of a tree in its flight it may actually be split or deformed before reaching its objective. On the other hand, a fully jacketed bullet often remains undamaged or only slightly deformed on striking, for example, a body. Less scrupulous shooters sometimes file the point of a fully jacketed bullet in order to produce the same effect as that of a semijacketed one. This result is obtained if the bullet leaves the barrel whole; however, because the jacket is open at both ends, there is a risk of the lead core only being driven out and the jacket remaining behind in the barrel. If this is not noticed, then when the next shot is fired the weapon will burst or a bulge will be produced in the barrel.

Lead bullets may be of different degrees of hardness. Bullets of soft lead are often greatly deformed and sometimes break up when they strike a body, while those of hard lead may retain their regular shape to the same extent as a fully jacketed bullet.

Ammunition intended for automatic pistols usually has fully jacketed bullets, while revolver ammunition usually has lead bullets. There are, however, also automatic pistol cartridges with lead or semijacketed bullets and revolver cartridges with fully jacketed bullets. An intermediate position is taken by the previously mentioned cartridges of .22 caliber with lead bullets, which can be fired in certain automatic pistols, single shot pistols, revolvers, and rifles. Also, as mentioned previously, revolver cartridges of .320 caliber, which are provided with lead bullets, can be fired in pistols of 7.65-mm caliber.

The type of jacket, if any, and the contour, weight, and composition of the bullet and the number, size, and design of cannelures may give an indication of the maker of the cartridge. In American cartridges, for example, lead bullets are sometimes copper plated. On a fired bullet the bore of the weapon will have left marks from the lands and sometimes also from the bottom of the grooves. A microscopic examination of these land and groove marks sometimes shows characteristic details that make possible an identification of the weapon. Furthermore, the number, width, and direction of twist of the lands and grooves make possible a determination of the make or makes of weapons from which the bullet may have been fired. The angle or rate of twist can be determined, but this is difficult and inaccurate when the projectile is mutilated.

The number and width of the landmarks, together with the direction and angle of the twist, vary for different manufacturers and types of weapons. Under no conditions should a bullet be tested in the bore of a weapon by pushing it into the muzzle, if the bullet and

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Figure 10.18 Automatic pistol cartridges (19-mm Luger) damaged by malfunctioning. The cases were jammed in the ejection port. *(Los Angeles County Sheriff's Department.)*

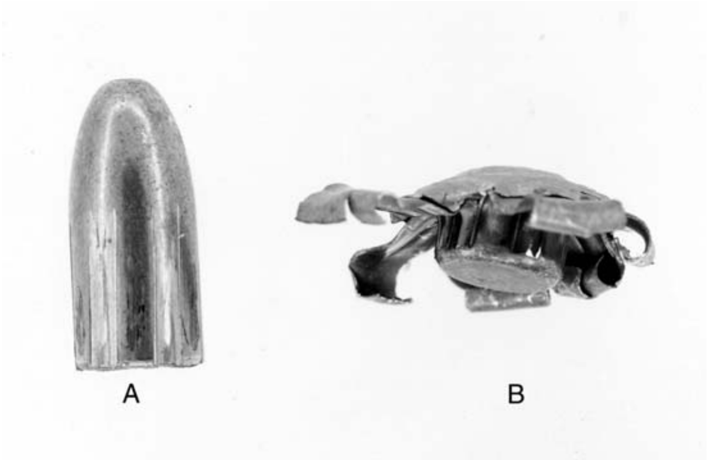

Figure 10.19 A fully jacketed bullet (A) is usually not deformed to any extent on striking an object (e.g., a body), but a semijacketed bullet breaks up (B). *(Los Angeles County Sheriff's Department.)*

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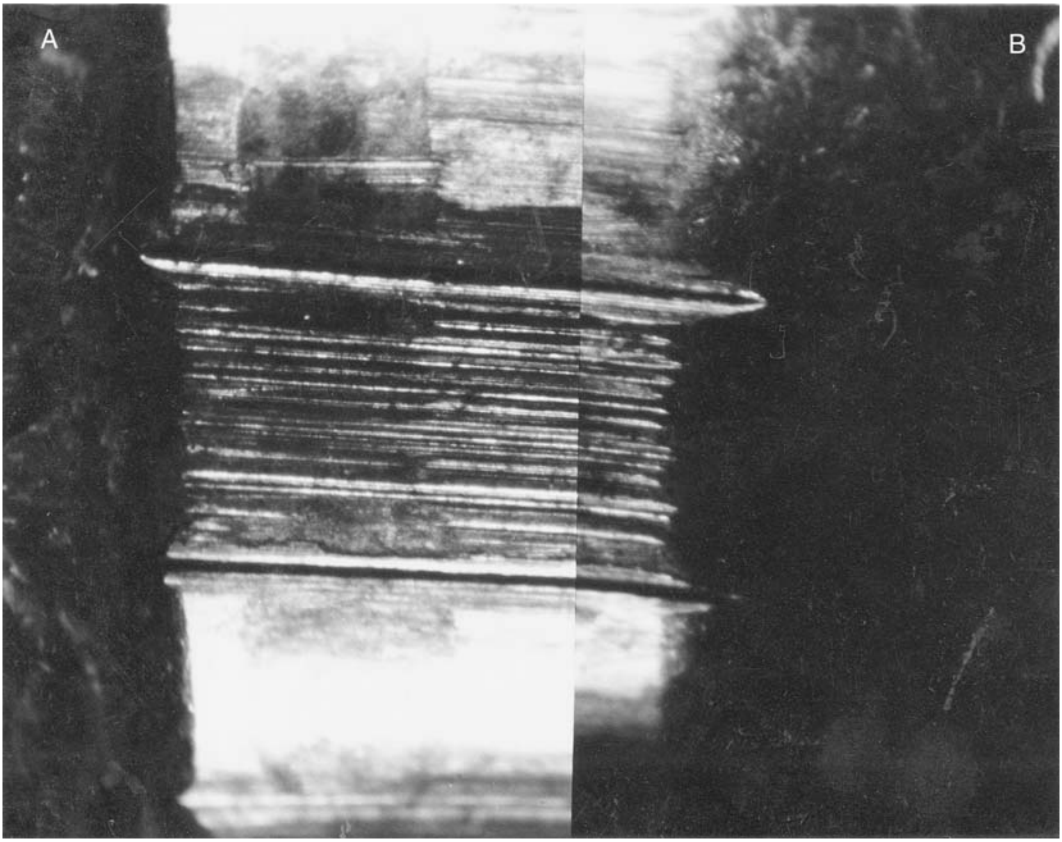

Figure 10.20 Identification in the comparison microscope of two jacketed rifle bullets of 9.3-mm caliber from the microscopic marks in the engravings of the lands: (A) bullet from the scene of the crime, (B) comparison bullet from the weapon of the suspect. Note the well-defined score in the mark of the land caused by one serious injury to the actual land in the bore of the weapon. *(Los Angeles County Sheriff's Department.)*

weapon are to be subjected to further investigation with the goal of identification. The microscopic marks on the bullet might be completely destroyed in this way. If it is necessary to search for a weapon in connection with a bullet that has been found, the police officer can obtain a useful guide from a study of the land marks on the bullet. The number of marks, their width, and the direction of the twist can be compared with a suspected weapon. If it is such a long time after the actual shooting that any deposit of dust or powder in the barrel would no longer be significant or if the barrel has evidently been cleaned or oiled, then a suitable piece of plasticine, molded to a point, can be introduced into the muzzle of the weapon to obtain an impression of the lands so that their number and width can be compared with the marks on the bullet. Otherwise, this information must be obtained from inspection of the muzzle of the weapon, possibly with the aid of a flashlight.

Generally, the number of "suspect" guns in any investigation is not large. Therefore, it is better to let the laboratory sort these weapons by firing test shots. A number of factors affect the width of land impressions so that an exact comparison between a cast of the barrel and the bullet cannot be made. Anything within a reasonable range of tolerance should be submitted for laboratory tests.

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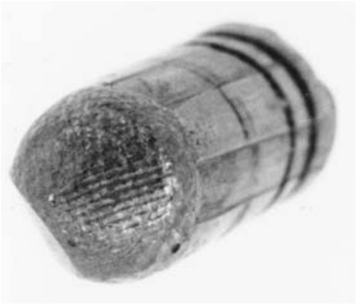

Figure 10.21 Fabric impression on the nose of a lead bullet denotes its passage through fabric. *(Los Angeles County Sheriff's Department.)*

If there is reason to suspect that a bullet that has been found has *ricocheted* and it is important to confirm this, it must be remembered that small grains of sand or other foreign matter may have stuck in flaws in the bullet, which should therefore be treated with care so that such particles do not fall off. Damage resulting from a ricochet can often be identified microscopically.

If a *muzzle-loading weapon* has been used it is possible that the bullet may show marks from the ramrod, so these should be looked for. Homemade bullets can possibly be identified with the mold used. In the case of muzzle-loaders it is also necessary to search at the scene of the crime for any paper wads or the like that might have been used in loading the gun. These often remain uninjured and the paper can perhaps be identified as torn from a newspaper or from a piece of paper in the possession of a suspect. Although the *rifled slugs and single balls* of lead sometimes used in shotguns may give an opportunity for identification of the weapon, they can give information only as to the caliber. Homemade balls can possibly be identified with the molds in which they were made.

Small Shot

At close range the charge of shot, which has not yet dispersed, makes a large wound in a body, but at longer range the shot spreads out, more or less depending on the degree of choking of the gun, barrel length and size, and amount of shot. The amount of spread gives an opportunity to estimate the distance of the shot. If scaled photographs of the wound or shot pattern are available, comparison shots can be fired using the suspect weapon and ammunition of the same make and vintage. These are usually fired at heavy poster board or blotting paper. Without scaled photographs or comparison tests, only very broad estimates are possible because the patterns produced by various combinations of guns and ammunition vary over a considerable range.

Table 10.1 gives an example of the influence of the degree of choke on shot patterns. These figures will not apply to all shotguns and all ammunition. At a distance of 5 to 8 yards or more from the place of firing, in the approximate direction of fire, one can sometimes find wads. The size of shot is sometimes given by a number, and sometimes shown by letters. There is no internationally uniform method of designation of shot; the procedure varies in different countries.

By measuring the diameter of any shot found, it is thus possible to find the size of shot that would be marked on the cartridge. In this connection it should be noted that

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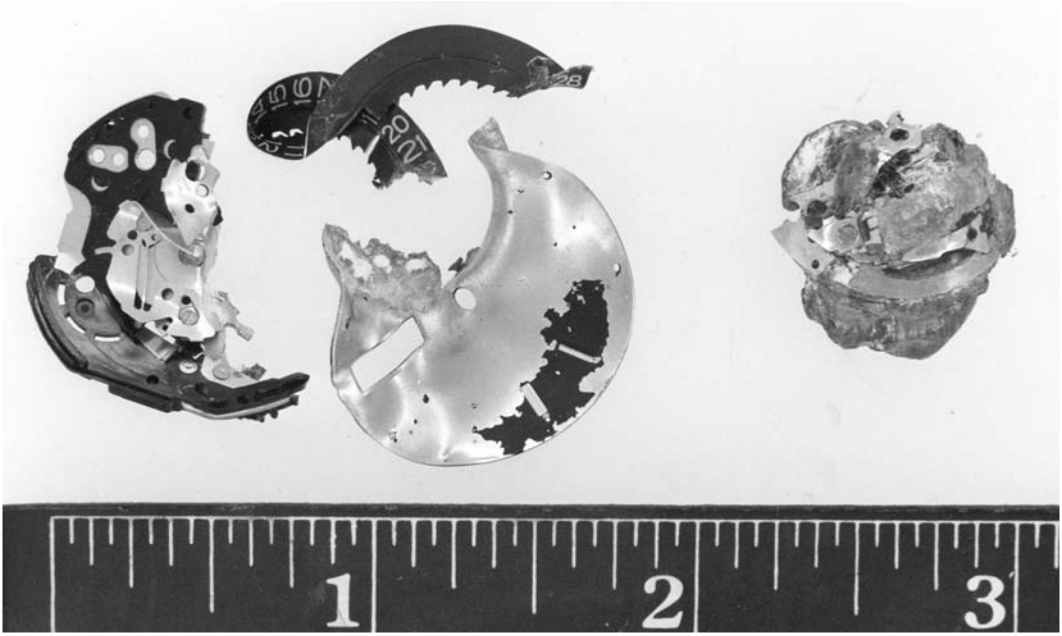

Figure 10.22 (A color version of this figure follows page 256.) A bullet with wristwatch parts embedded in the nose and a damaged watch recovered at the scene. *(Los Angeles County Sheriff's Department.)*

Table 10.1 Diameter in Inches of the Spread at Various Ranges of a Shotgun Charge

	Range in Yards						
Boring of gun	10	15	20	25	30	35	40
True cylinder	19	26	32	38	44	51	57
Improved cylinder	15	20	26	32	38	44	51
Half choke	12	16	20	26	32	38	46
Full choke	9	12	16	21	26	32	40

there might be certain minor variations in size of shot in one and the same cartridge. It is therefore important to collect as many pellets as possible so that the determination is more reliable. Often the shot is deformed to such an extent that it is impossible to measure its diameter with the desired accuracy. In this case, it is convenient to weigh as large a number of shot as possible, calculate the mean weight, then weigh the same number of shot from cartridges with the different sizes of shot that may be in question and calculate their mean weight for comparison.

If a weapon is sent to an expert to determine whether a bullet or a cartridge case has been fired from it, a sufficient number of cartridges (five to six or more) of the same type as that used in the actual incident should be sent with it. This is particularly necessary if powder or shot patterns are to be fired. All ammunition in the weapon and any partial boxes of unfired ammunition associated with victim or suspect should be submitted with the weapon. Sufficient differences may exist between ammunition found in the gun and

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other ammunition available to the expert so that comparison tests are difficult, doubtful, or impossible.

If a number of tests must be fired for comparison and transmission to various laboratories, inquiries should be made as to the nature and make of test ammunition desired in each investigation. For best results, these test specimens should be obtained by a laboratory and not by the field investigator.

Test Firing

Test firings of a weapon must be done so that the bullet can be recovered undamaged. For all jacketed bullets and most types of lead bullets, a cotton wad box or water trap is used to stop the bullet. With a cotton wad box, as a consequence of its rotation, the bullet twists itself up in the waste, which finally forms a ball around the bullet, and the velocity progressively decreases until the bullet is finally held in the cotton waste. Occasionally, long staple surgical cotton is placed in front of the cotton waste. This forms a ball around the bullet, further protecting the surface. Because of the mild damage to the bullet's surface due to the abrasive action of the cotton, water is frequently used as a collecting medium. For the collection of projectiles fired from handguns, 5 to 6 feet of water is ample. Generally, it is undesirable for the police officer to carry out test shots with the weapon personally because the microscopic imperfections in the bore of the weapon may be destroyed in the process. It is particularly important that the expert have an opportunity to examine the weapon before any tests are fired.

Powder Pattern Examination

When a weapon is fired at close range (up to several feet), burned and sometimes unburned particles of gunpowder are discharged onto the target. This effect is referred to as powder pattern deposit. The appearance of the powder pattern is sometimes helpful in establishing the distance from the fired weapon to the target. If the weapon was fired perpendicular to the target, the resulting powder pattern distribution will be located in an approximately circular area around the bullet entry hole.

The diameter of the circle and the distribution of particles can be used to establish the distance. Type of firearm, barrel length, and type of ammunition are all factors that affect the size and density of the powder pattern. If the muzzle of the weapon is in contact with the skin or within approximately 1/2 inch, the powder pattern is generally absent. This is due to the lack of space available for expansion of the powder, so that at close range it will penetrate the body through the entrance wound.

To make a distance determination, it is important to use the same firearm and ammunition used in the crime. A series of test firings are made into paper or cardboard at different distances and the test patterns are compared with the evidence. In most instances it is also useful to make the tests on material the same as or similar to the evidence.

In certain instances the powder pattern is not easily visible. Bloodstained or dark-colored clothing causes these difficulties in visualization. Infrared photography is helpful in bloodstained clothing cases. Chemical tests for nitrates present in the gunpowder, such as the *Walker test* or *Griess test* or, for lead and barium in the primer, the *sodium rhodizonate test,* are useful in developing the powder pattern.

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Figure 10.23 (A color version of this figure follows page 256.) A NIBIN workstation consisting of a microscope and computer terminal linked to the NIBIN database. *(Los Angeles County Sheriff's Department.)*

National Integrated Ballistic Information Network (NIBIN)[2]

In the past, comparing firearms evidence from one investigation to that of another was almost impossible unless there was some connection between the cases. Typically, the investigator determined or thought it possible that the same gun was used in two cases and asked the firearms examiner to compare the two recovered bullets or shell casings.

NIBIN is a networked computer database of fired cartridge casing and bullet images used by crime laboratories. The system was developed to link firearms evidence and to solve open cases by allowing firearms examiners to compare evidence with fired bullets, cartridge casings, shotgun casings, and firearms recovered in other jurisdictions. By means of a microscope attached to the system, images of bullets and cartridge casings are electronically scanned and stored for later retrieval and comparison with other case images. The system has the ability to compare the new images rapidly with images in regional and national databases. The firearms examiner visually compares the images to determine if there is a hit (Figure 10.23).

[2] See the NIBIN web page at http://www.nibin.gov/.

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The value of these systems is their ability to associate firearms evidence between unrelated crimes. Test firing confiscated firearms that come into the custody of the police becomes even more important because of the possibility of developing more information about cases that have appeared to be unrelated.

Firearms evidence occurs in many crimes, such as assault, murder, and the like, and is particularly important because of the large amount of useful information it can provide. Because this type of evidence is encountered so frequently, investigators must be familiar with the proper methods of handling it and its value to the case.

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11

Arson and Explosives

Arson is defined as the willful and malicious burning of another's property or the burning of one's own property for some illegal purpose such as defrauding an insurer. As a crime, arson ranks only behind traffic-related incidents in the highest losses of life and property. In dollars, property losses due to arson can be placed in the billions of dollars annually.

Arson investigation[1] requires a considerable amount of care, attention to detail, and skill on the part of the investigator. Arson scenes present a host of problems that are uncommon to most other crime scene investigations. In most criminal investigations, once the crime has been committed and the police notified, the scene may be secured in relatively the same condition in which it was found. This is anything but the case in fire investigation. By the time the arson investigator arrives on the scene, numerous individuals including fire fighters, supervisory personnel, onlookers, and possibly the owner of the property will have visited the crime scene. The preservation of the crime scene is frequently the last things to be considered by firefighters when "knocking down" a blaze.

The issue of criminal intent is another major difference in arson investigations compared with other investigations. With most other crimes, the investigator frequently knows on arrival or shortly thereafter that a crime has been committed. With arson cases, determining whether a fire was set accidentally or intentionally may require considerably more investigation.

Arson and explosion crime scenes are unique in the amount of destruction and devastation present. An item that normally is identifiable as important evidence in an investigation can be totally or partially destroyed by the fire or by fire fighters. In spite of the difficulties inherent in arson investigation, a careful and thorough search of the fire scene can produce much useful information.

A number of motives are frequently associated with arson. Probably the most common motives are concealment of other crimes and defrauding an insurance company. A fire investigator frequently finds that the fire was set to cover up another crime such as murder, burglary, embezzlement, or fraud. The attempt in these cases is to destroy records and evidence of the crime that could make identifying the suspect or the victim of a murder impossible. In insurance fraud cases the suspect may have suffered a business reversal or

[1] The U.S. Department of Justice, National Institute of Justice, publishes *Fire and Arson Scene Evidence: A Guide for Public Safety Personnel*, available on the web at: http://www.ncjrs.org/pdffiles1/nij/181584.pdf; The International Association of Arson Investigators has a web page at http://www.firearson.com/: The National Fire Protection Association is another important association. Its web site is located at http://www.nfpa.org/; The National Association of Fire Investigators has a web site at http://www.nafi.org/.

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Figure 11.1 The scene of an arson fire at Universal Studios in Los Angeles showing the clock tower from the movie *Back to the Future.* (*Los Angeles County Sheriff's Department.*)

be heavily in debt. The fire is set to appear accidental with the intent of filing a false insurance claim. Other motives such as malicious mischief caused by juveniles, revenge, extortion, sabotage, terrorist acts, and pyromania all represent potential reasons for setting fires.

The arson investigator should focus the investigation to answer several questions:

1. **Where did the fire originate?** Information can be obtained by questioning fire fighters about the location of hot spots, in which direction the fire was moving, how fast, etc. The most information will be gained by going through the scene and noting what areas suffered the most fire damage and exposure to heat. The origin of the fire is evidenced by the depth of char on burned items, degree of destruction, spalling, metal or glass bent or melted by exposure to heat for a longer time than other areas, and burning or heat fading of paint. Be alert to multiple sources or the entire structure as the origin.
2. **How was the fire started?** The investigator should look for faulty electrical wiring, the presence of igniters, matches, ignitable material, kindling, and other means of starting the fire. Ignitable fluids will run into cracks and under objects on the floor and cause burning in locations that would not normally burn. They will also char deeper in areas where they were located, sometimes burning through the floor.
3. **Was the cause of the fire an accident or was it intentionally set?** This is the key issue in determining whether the fire was arson. Evidence such as breaking into and entering the building, presence of ignitable fluids, and multiple points of origin may indicate a maliciously set fire.

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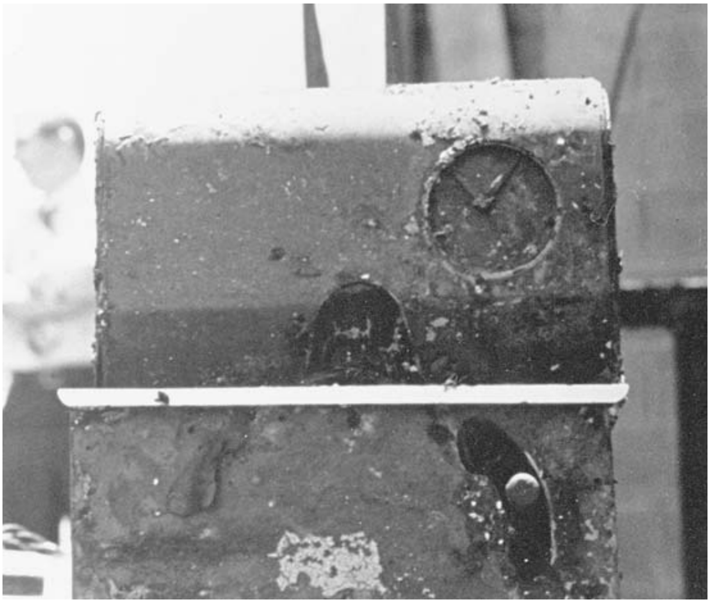

Figure 11.2 A burned-out electrical timer device located at a fire scene can give the approximate time at which the power went out as a result of the fire. *(Los Angeles County Sheriff's Department.)*

Physical Evidence

The presence of ignitable fluids is the most commonly sought physical evidence in arson investigation. Even in cases in which fire damage was particularly extensive or the scene was completely wetted down, there is still a good probability of detecting ignitable fluids. The search for ignitable fluids should be concentrated at the point where the fire started. If charred rags or carpeting is noted, these should be collected and sent to the laboratory. Wood flooring, furniture, and carpet padding into which gasoline or kerosene may have been absorbed should also be collected as well as empty containers or broken glass jars found at the scene.

Ignitable fluids are highly volatile and evaporate easily. For this reason, appropriate packaging must be used to preserve these items for laboratory analysis. Packaging evidence in paper or plastic bags or containers will not preserve it. Such packages allow volatile liquids to dissipate completely. The best manner of packaging these items is in clean metal paint cans. The items should be placed into the cans, which should then be tightly sealed with metal lids. An alternative method of preserving evidence is to use glass jars with metal screw-cap lids. Metal and glass containers retain small amounts of liquids and vapors that can be analyzed by the crime laboratory. The quantity of material needed for chemical analysis of an ignitable substance is extremely small. Laboratory instruments are capable of readily identifying ignitable liquids in quantities of less than a fraction of a drop. In fact, if an odor of an ignitable liquid can be detected, there is a good chance that a forensic lab can identify the source.

Laboratory analysis can differentiate among the many types of accelerants used in arson cases. The common types are gasoline, kerosene, charcoal lighter fluid, paint thinner,

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Figure 11.3 A melted aluminum awning indicates the approximate temperature of the fire. Aluminum melts at 660.2°C. *(Los Angeles County Sheriff's Department.)*

and turpentine. In some cases the dyes contained in gasoline can be used as a means of comparison with known samples. Highly sophisticated scientific instrumentation at some laboratories may be able to differentiate brands of gasoline.

A careful search of all entrances and windows should be made to determine whether the building had been forcefully entered. If tool marks are observed, the area should be cut out or an impression made and submitted to the laboratory. Also, samples of building materials such as glass, paint, plaster, stucco, wallboard, cement, etc. that may have been deposited on the suspect's clothing should be collected for purposes of control or known samples. All evidence must be properly marked for identification and packaged properly. In some instances, an apparent forced entry might have been used to cover up arson, so such things as the side from which a window was broken, screen cut, etc., should be checked.

The investigation should include the search for igniting materials; burned matches and matchbooks should be collected. Burned matches, in some cases, can be physically fitted into a matchbook found on a suspect and matchbooks can be chemically processed for fingerprints. Occasionally, pieces of a timing device used to delay the ignition of a fire may be discovered.

Other types of igniters such as candles, black powder, smokeless powder, sodium and water, electrical devices, and similar items should be noted and collected. It is important that the manner in which the fire started be established. This determines the M.O. (*modus operandi*) of the arsonist.

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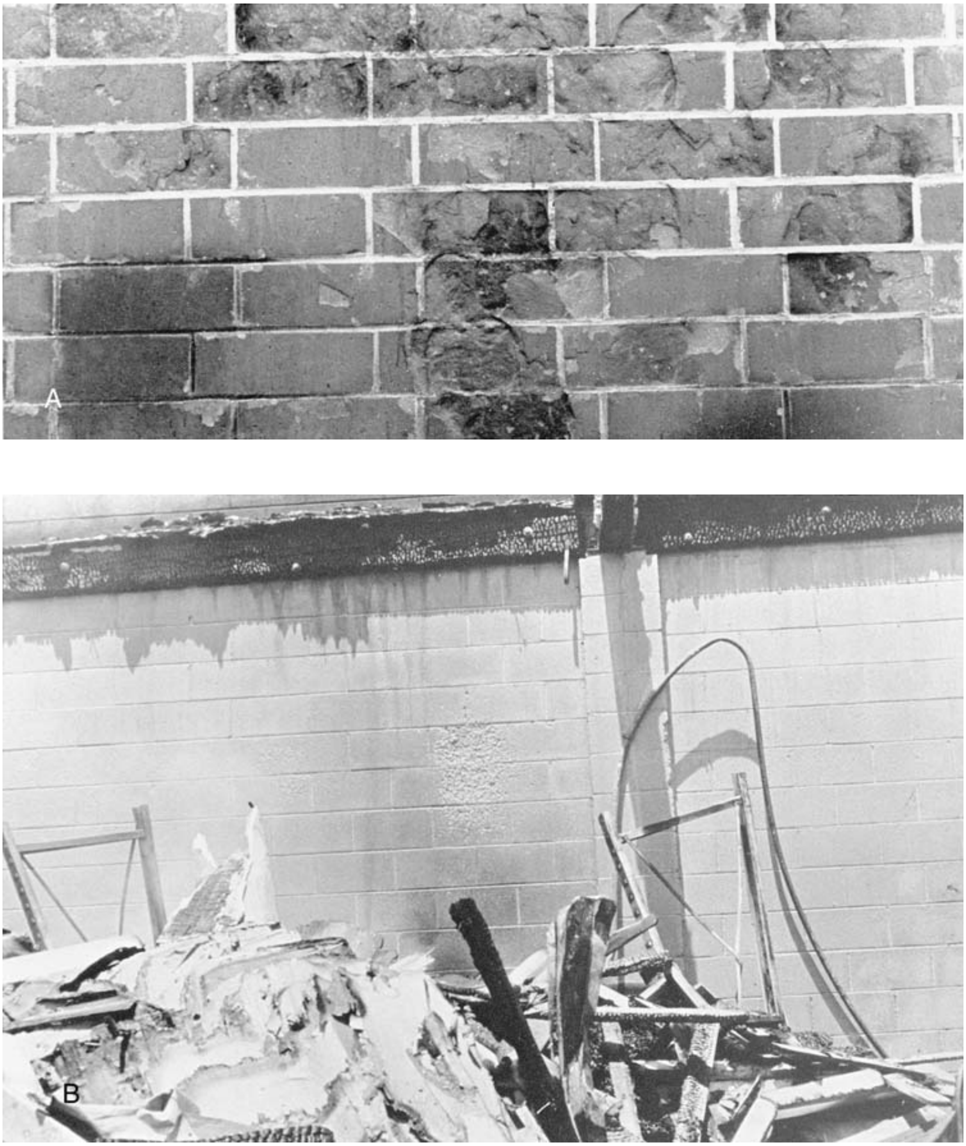

Figure 11.4 These photographs depict (A) chipping or splintering, commonly known as spalling, on a brick wall caused by a hot spot at the scene and (B) another example of spalling on a cinder block wall. *(Los Angeles County Sheriff's Department.)*

If the scene of the arson is a business establishment, the investigator may notice that file cabinets have been pulled open and papers strewn about. Burned papers should be carefully collected and placed into cardboard boxes, handling them as little as possible. Burned paper may be examined at the laboratory and useful information can be determined. For example, it may be very beneficial to know what files were burned or are missing.

If the fire was started outdoors, the area of the origin of the fire should be examined. Soil from that area should be collected and tested for the presence of ignitable materials. To accomplish this, a clean, gallon paint can should be filled with soil, sealed, and submitted to the laboratory along with a control sample.

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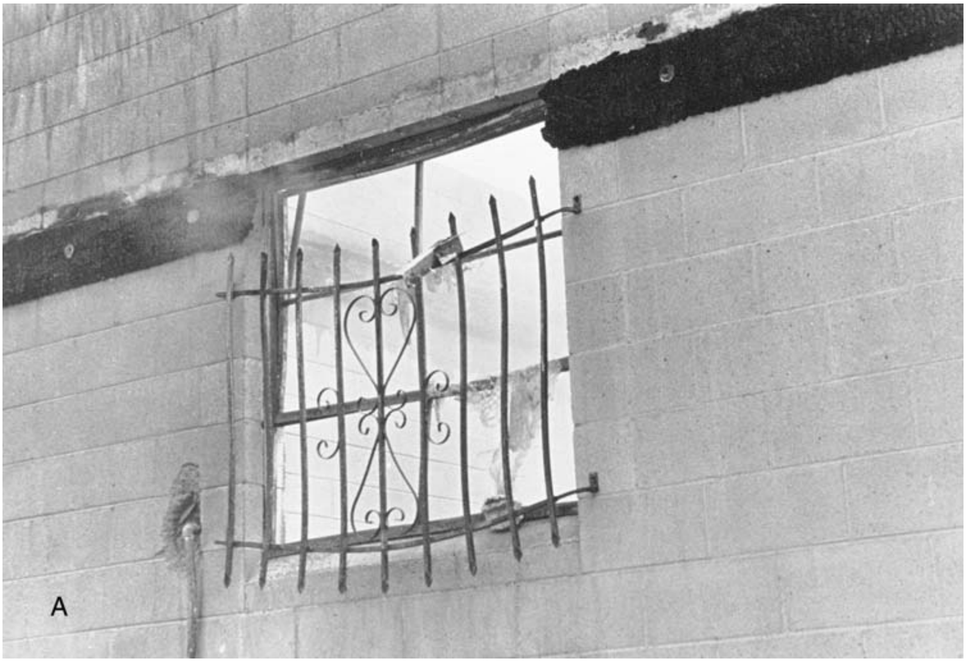

Figure 11.5 (A) Melted safety glass may indicate exposure to heat for a period of time, thereby suggesting a point of origin of the fir**e.** (B) Deformed pipe as a result of the heat of the fire. (C) Typical appearance of burned lumber, referred to as "alligatoring," indicating the surface texture of the burned wood. *(Los Angeles County Sheriff's Department.)*

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Figure 11.5 (continued)

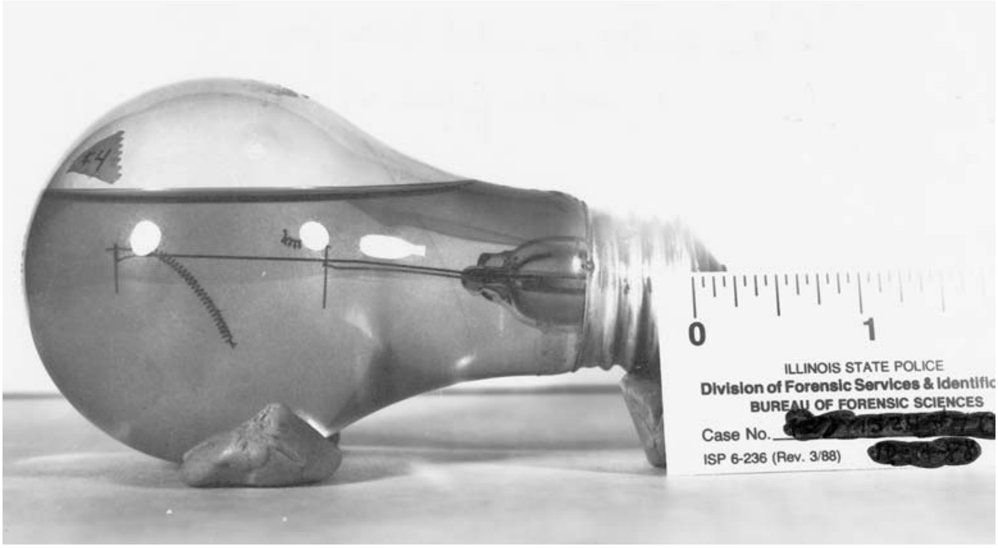

Figure 11.6 This incendiary device, a light bulb with a small hole drilled into the base, filled with medium petroleum distillate, and sealed with a putty-like material, was found in a light socket connected to a timer in a house under construction. The device probably would not have worked because too much liquid was in the bulb, which covered the filament. *(Illinois State Police, Bureau of Forensic Sciences.)*

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Figure 11.7 A portion of a "Molotov cocktail" with a shot shell. *(Illinois State Police, Bureau of Forensic Sciences.)*

Any items left at the scene by the arsonist should be preserved. Traces such as pieces of clothing, hair, blood, tools, broken tools, etc. may prove to be important as a means of establishing identity of the suspect.

When a suspect is apprehended, a careful search of his property should be made to determine whether anything can be tied to the crime or the crime scene. Any accelerants such as gasoline or kerosene should be packaged and submitted to the laboratory for comparison with solvents detected at the scene of the arson. Similarly, objects such as tools, matches, matchbooks, incendiary devices, and the like should be collected. The suspect's clothing and shoes should be collected, packaged, and sent to the laboratory for examination for the presence of these materials.

The suspect's vehicle should be inspected for the presence of material removed from or transported to the scene of the arson. Any search of the suspect's vehicle or residence may require a search warrant. The local prosecutor should be contacted if there is any question.

In cases in which a dead body is discovered in the investigation, a determination of the cause of death is necessary to ascertain whether the victim died as a result of the fire or the fire was set in order to conceal the killing. The pathologist will be able to determine at the time of the autopsy whether the person died of smoke inhalation or was dead prior to the fire.

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Figure 11.8 An improvised incendiary device consisting of a cigarette and matches can produce sufficient heat to cause the contents of the bag to burn. *(Los Angeles County Sheriff's Department.)*

Explosives[2]

Explosives are useful tools by which people have accomplished some remarkable engineering feats. However, like many other things, explosives are used for criminal ends as well. Murder, burglary, extortion, terrorist activities, and similar activities involving explosives require the attention of the investigator. Bomb scene investigation is frequently treated as a specialty within some police agencies and is often associated with arson investigation. Although certain aspects of crime scene investigation of bombings differ from a common crime scene, the basics remain the same.

[2] The International Association of Bomb Technicians and Investigators has its web site at http://www.iabti.com/.

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Figure 11.9 Examples of boosters, blasting caps, and dynamite. *(Los Angeles County Sheriff's Department.)*

In broad terms, an explosive is a material capable of rapid conversion from either a solid or a liquid to a gas with resultant heat, pressure, and loud noise. Many chemicals, alone or in combination, possess the necessary properties for an explosive. Except for chemical compounds classed as explosives, the rest usually come to the investigator's attention only as the result of some accident. In such cases, consultation with a forensic chemist or criminalist will provide a satisfactory explanation for the explosion.

Explosives can be classed into two broad groups: low explosives and high explosives. High explosives consist of primary and secondary explosives; low explosives burn rather than explode. Damage by low explosives is caused by the force exerted by the rapid expansion of gases formed by burning. These types of explosives must be confined to explode. High explosives, in general, are detonated by shock and have much higher detonation velocities; they need not be confined to explode.

Low Explosives

Black powder is the most common type of low explosive. It is a mixture of potassium or sodium nitrate, sulfur, and charcoal. There has been wide variation in the formulation of this mixture over the years. Black powder is sensitive to heat, impact, friction, and sparks. When placed into a confined area, such as a pipe bomb, black powder can be a destructive explosive. Detonation can easily be accomplished by means of a safety fuse. If an unexploded pipe bomb is encountered, it is very important to exercise extreme care in opening

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Figure 11.10 Debris from a pipe bomb packed with a low-order explosive. *(Los Angeles County Sheriff's Department.)*

the device because it can be set off by friction. One of the most common uses of black powder is in the manufacture of safety fuses.

Safety fuses are used to initiate explosives nonelectrically; they are generally composed of black power with a protective covering of cotton yarn or jute followed by an asphalt layer for water resistance. The asphalt covering is then covered with an insulating material such as a polyethylene plastic covering or a wax-impregnated yarn jacket. The color of the fuse is generally white, black, or orange.

Safety fuses should normally burn at a definite rate of speed, but may burn faster or slower depending on several factors such as age, handling, altitude, and humidity. Usually, they burn at about 30 to 40 seconds per foot; however, the actual rate should be determined by testing a given length (Figure 11.11).

Smokeless powder is another low explosive encountered in bomb investigations. It is mainly used for small arms ammunition but is frequently used in pipe bombs. Two types of smokeless powder are marketed: single and double base. Single-base smokeless powder consists of nitrocellulose, while double-base is composed of nitrocellulose and nitroglycerine. Although smokeless powder is not as sensitive to friction as black powder, it should be handled with the same amount of care.

High Explosives

Primary explosives detonate when subjected to heat or shock. They are typically used as initiators of high explosives, to detonate main charges, and in blasting caps and firearm primers. For this type of explosive, the major interest in bomb investigation is in blasting

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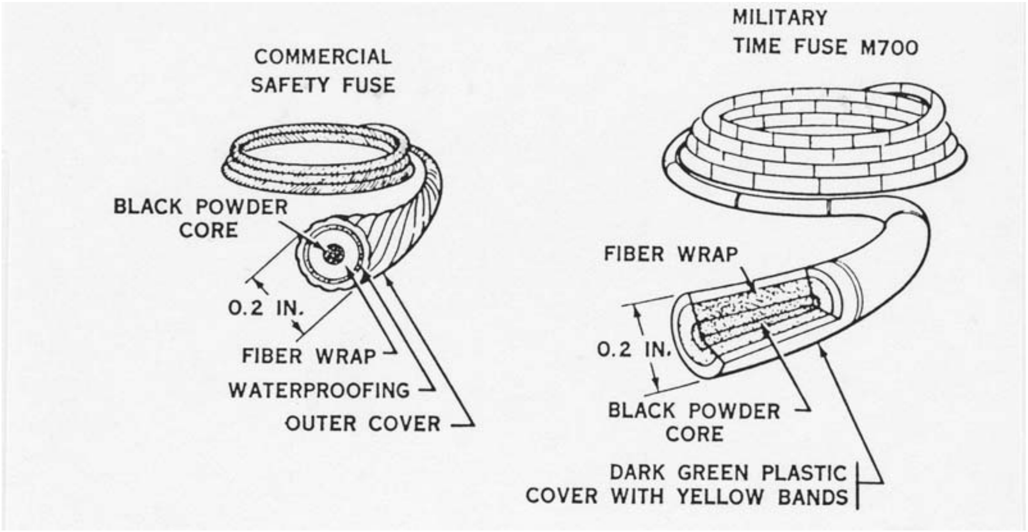

Figure 11.11 Safety fuses. *(U.S. Department of Justice.)*

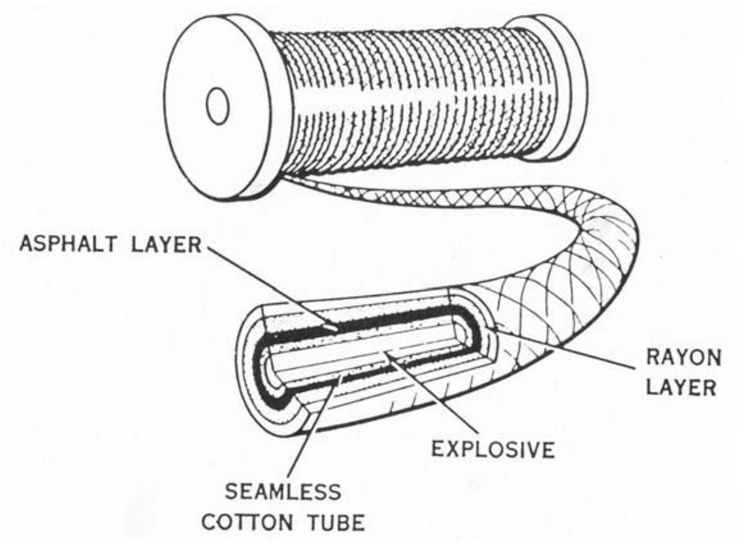

Figure 11.12 Detonating cord. *(U.S. Department of Justice.)*

caps. *Blasting caps* are of two types: electric and nonelectric. They are small explosive devices, about 1/4 inch in diameter and from 1 to 3 inches in length. The case may be made of aluminum, copper, or bronze. The electric blasting caps have colored wires extending from them.

Secondary explosives detonate by shock from a suitable primary explosive. Their detonation velocities range from 3300 feet per second in the case of ammonium nitrate to 29,900 feet per second in the case of HMX. Typically, high explosives are used to shatter or destroy objects.

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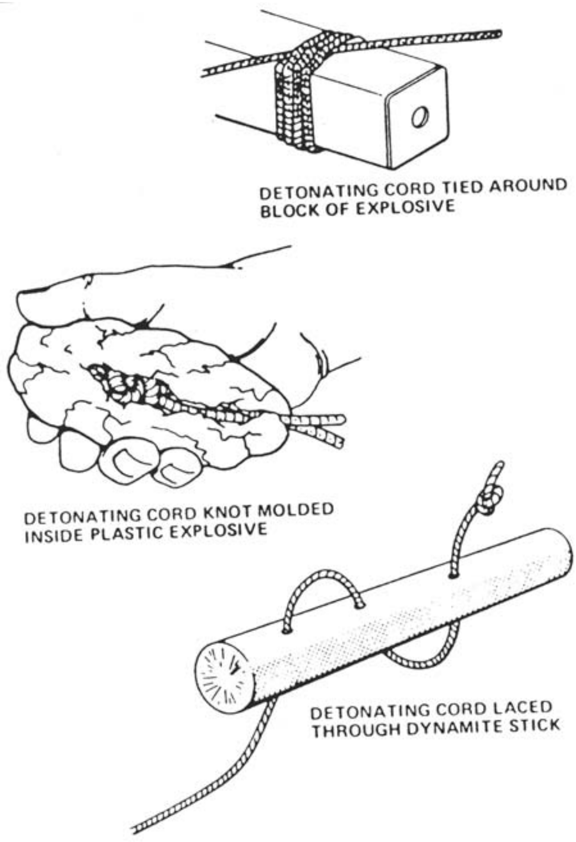

Figure 11.13 Examples of use of detonating cord to prime explosives charges. *(U.S. Department of Justice.)*

Detonating cord is a cord-like explosive, similar in appearance to a safety fuse. It contains a central core of RDX or PETN covered with cotton or other textile, followed by a waterproof material or plastic covering. The cord detonates at velocities from 18,000 to 23,000 feet per second. It is very insensitive to shock and heat and presents no special problems in handling. Detonating cord is used to set off charges of high explosives much in the same way as a safety fuse is used to set off multiple pyrotechnic devices. The detonating cord may be inserted, tied, or knotted inside the high explosive to initiate detonation. Detonating cord is used to set off simultaneous charges and is detonated by means of a blasting cap (Figures 11.12 and 11.13).

Boosters or primer explosives are used to detonate very insensitive high explosives. The booster consists of a secondary explosive such as RDX, PETN, tetryl, or pentolite and is detonated by means of a blasting cap. Boosters are usually cylindrical in shape with a small opening to permit insertion of a blasting cap.

A large number of high explosives are used commercially and by the military. Next, some of the more common ones encountered in law enforcement work are detailed; however, the list is not intended to cover all of the many types.

Nitroglycerine was first developed in 1847, but it was not until 1867 that Alfred Nobel developed a method to desensitize this explosive sufficiently so that it could be used

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commercially. Nobel's invention, *dynamite*, was a mixture of nitroglycerine and diatomaceous earth. Today, dynamite contains EGDN (ethyleneglycoldinitrate) in addition to other materials used to desensitize the nitroglycerine. Inert materials such as wood pulp or sawdust, cornmeal, sodium nitrate, and many other materials are found in dynamite, which is usually packaged in cylindrical sticks and wrapped in waxed paper. The sticks come in a variety of sizes; the most common is 1 1/8 to 1 1/2 inches in diameter and 8 inches in length. Other sizes may be as large as 12 inches in diameter and 4 to 36 inches long. There are four basic types of dynamite in use today: straight dynamite, ammonia dynamite, gelatin dynamite, and ammonia–gelatin dynamite.

Straight dynamite — manufactured in strengths of 15 to 60% by weight of nitroglycerine. The nitroglycerine is generally absorbed onto a material such as wood pulp or ground meal (such as cornmeal, cornstarch, or the like). Dynamite has a sweet, pungent odor and frequently may cause headaches. Straight dynamite has an oily, slightly moist appearance and resembles a mixture of oil, sawdust, and clay. In older sticks of dynamite, the outer wrapper may often look oil-stained from the nitroglycerine seeping out of the mixture. Police should treat such dynamite with extreme caution because it is in a highly unstable form.

Ammonia dynamite — some of the nitroglycerine is replaced with ammonium nitrate. Ammonia dynamite is less sensitive to shock than straight dynamite and has less of a shattering effect, but is more suitable for "pushing." The color of ammonia dynamite is light brown, compared with a slight reddish tint in the case of straight dynamite.

Gelatin dynamite — a water-resistant form of dynamite manufactured by combining nitroglycerine with nitrocellulose. The resulting "gel" forms a thick, viscous liquid useful under wet conditions.

Ammonia–gelatin dynamite — a combination of the last two formulations. The addition of the ammonium nitrate is a cost-saving factor and the gelatin allows the explosive to be used in wet conditions.

Ammonium nitrate is a readily available material used as an explosive and, in a less pure form, as a fertilizer. In its pure form it is a white crystalline material but may be a light tan color in a less pure form. As an explosive it is relatively insensitive and requires a booster charge to be detonated. Because of its easy availability as a fertilizer, although less pure than explosive grade ammonium nitrate, it is readily available for use in homemade bombs. A modification of ammonium nitrate sometimes used is a mixture of ammonium nitrate and fuel oil, also known as ANFO.

Water gels or slurries are classified as either blasting agents or explosives, depending upon what they contain and whether or not they are cap-sensitive. Water gels typically have an ammonium nitrate base, a sensitizer, a thickener, and 5 to 40% water. The sensitizer may be an explosive such as TNT, nitrostarch, or smokeless powder, or it may be a nonexplosive such as sugar, fuel oil, carbon, or a powdered metal. These explosives are rapidly gaining in popularity as substitutes for dynamite. Most slurries require a primer or booster for detonation; however, some manufacturers make cap-sensitive gels.

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Blasting Agents

Blasting agents, also known as nitrocarbonitrate (NCN), are insensitive chemicals and chemical mixtures that are detonated by means of a high-explosive primer or booster. In order to be classified as a blasting agent, the material must be unable to be detonated by a No. 8 blasting cap and contain no high explosives such as TNT or nitroglycerine. Blasting agents consist largely of ammonium nitrate. ANFO is considered a blasting agent and consists of 94% ammonium nitrate and 6% fuel oil. The advantage of blasting agents is that safety regulations governing shipping and storage are considerably less severe than those applicable to high explosives.

Binary explosives are two inert, nonexplosive chemicals that, when mixed, form a cap-sensitive high explosive. The materials are either both liquids or a powder and a liquid; in their unmixed states they are very insensitive to shock or friction. One component is usually ammonium nitrate, while the other is a nonexplosive sensitizer.

Military Explosives

Sheet explosives are flexible, rubber-like sheets approximately 1/4 inch thick that can be cut with a knife. These explosives are used in commercial and military circumstances. The high explosive used is either RDX or PETN. Sheet explosives are known as Flex-X, Datasheet, or M118 Demolition Block (the latter military sheet explosives). The most common type of military explosive is *trinitrotoluene (TNT)*. Military explosives differ somewhat from commercial explosives in that they must be used in combat conditions. Typically, they must be relatively insensitive to heat, shock, friction, and bullet impact, have high destruction power (brisance), be lightweight and convenient to use, be usable under water, etc.

TNT is generally encountered in military explosives in 1/4-, 1/2-, and 1-pound blocks. The blocks have metal ends with a threaded well at one end for a blasting cap. The container is cardboard and the TNT is a light yellow to brown color although some newer formulations of TNT may be gray due to the addition of graphite.

RDX is used in the so-called *plastic explosives*. Plastic explosives contain plasticizers in addition to RDX and are easy to mold in warm temperatures.

Composition C-3, containing 77% RDX, is a yellow putty-like material that has a distinctive heavy, sweet odor. When molded, it will stain the hands and clothing. The M3 block is enclosed in glazed paper that is perforated around the middle for ease in breaking open and weighs 2 1/4 pounds. The block does not have a cap well.

Composition C-4 is replacing C-3 in military use. C-4 contains 91% RDX, is white to light brown in color, has no odor, and does not stain the hands. The M5A1 block demolition charge contains C-4 in a clear white plastic container with a threaded cap recess at each end. It weighs 2 1/2 pounds. Composition C-4 also comes in the M112 block demolition, an improvement of the M5A1 that replaces it as a standard issue. The M112 contains 1 1/4 pounds of composition C-4 with a pressure-sensitive adhesive tape on one surface, protected by a peelable paper cover. The C-4 in some blocks is colored dull gray and packed in a clear Mylar-film bag. In blocks of more recent manufacture, the C-4 is white and packed in an olive drab Mylar bag.

Military dynamite is not really dynamite, but a mixture of 75% RDX, 15% TNT, 5% SAE 10 motor oil, and 5% guar flour. It is packaged in waxed manila paper and marked

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M1, M2, or M3. Military dynamite is buff-colored granular material that crumbles easily and is slightly oily to the touch. It does not have the characteristic odor usually associated with dynamite because it contains no nitroglycerine.

The explosives discussed to this point are some of the more common ones encountered and represent explosives available through commercial and military sources. The explosives industry, however, is a rapidly changing one and the reader should understand this when studying the subject. It is suggested that the investigator consult explosive manufacturers, law enforcement agencies that routinely deal with explosive cases, and forensic science laboratories for the latest information on the subject.

Homemade Explosives

If commercial or military explosives are not available, it is not particularly difficult for an individual to improvise from a large number of chemicals that, when mixed together, can produce highly destructive explosive devices. The investigator should recognize at least some of the more common materials that often find their way into homemade explosive devices (Figure 11.14).

Materials such as starch, flour, sugar, cellulose, etc. can be treated to become effective explosives. Powder from small arms ammunition and from firecrackers, match heads, and ammonium nitrate from fertilizers can be used in explosive devices. To detonate an improvised explosive device, several methods are available:

- **Blasting caps.** Caps, especially electrical blasting caps, lend themselves to homemade bombs. Such devices may be set off by a timing mechanism, by movement, by wiring into an automobile ignition system, etc.
- **Percussion primers.** Primers from shotgun, rifle, or pistol ammunition are sometimes used to detonate explosives that are heat sensitive.
- **Flashbulbs.** Flashbulbs may be used to ignite heat-sensitive explosives such as black powder. If the bulb is placed in contact with the explosive, the resulting heat from the flashbulb will ignite materials such as black powder, smokeless powder, incendiary mixtures, etc. As mentioned earlier, because of its relative ease to manufacture, black powder is frequently used in homemade bombs.
- **Match heads.** Match heads are frequently found confined inside pipe bombs. They are sensitive to heat, friction, and shock and when confined in this type of device can produce an effective explosion.
- **Smokeless powder.** Powder from ammunition or for reloading purposes is frequently used as the main charge in pipe bombs.
- **Ammonium nitrate fertilizer.** Ammonium nitrate mixed with fuel oil and an appropriate booster makes an extremely effective homemade explosives device.
- **Potassium or sodium chlorate.** These compounds and sugar are used as incendiary and explosive materials.

The list of possible chemicals for improvised explosives is endless. Officers who come upon locations with large numbers of chemicals such as nitrates, chlorates, perchlorates,

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Figure 11.14 (A) Debris from a homemade explosives device with a timing mechanism. (B) An example of an unexploded homemade device with a timer. *(Los Angeles County Sheriff's Department.)*

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nitric acid, aluminum powder, magnesium, sodium, sulfur, charcoal, sugar, and sulfuric acid, to name just a few, should be aware that the location may be one where homemade explosives are made.

Bomb Scene Investigation[3]

Physical evidence in bombing cases is useful in answering many questions. Some of the questions that the investigator will be interested in answering are:

- What materials were used to make the explosive device?
- What was the level of skill or expertise of the suspect?
- What was the target of the bomb?
- Was the explosion accidental or was there criminal intent?
- Where was the bomb made?
- Where was the bomb placed?
- Where did the suspect obtain the material to construct the device?
- Who was the victim or intended victim?
- Who made the bomb and who placed it?
- How was the bomb detonated?

The nature of the target, whether or not the bomb exploded, the extent of damage, the location of the incident, and weather conditions are some of the factors that influence the action to be taken by the investigator. If a bomb is found that has not exploded, it is necessary to call in a bomb technician to render the device safe. The first priority of the technician is to disarm the bomb safely. If possible, the investigator should photograph the bomb prior to moving it and have the bomb technician note any changes made in the device when dismantling it. If the bomb must be exploded to be disarmed, it should be done in such a way as to avoid total destruction of the device.

The scene should be thoroughly searched for evidence that may have been left by the suspect. Collection of evidence should include a search for a forced entry and accompanying tool marks, fingerprints, footprints, and any other traces that may help link a suspect to the crime scene.

In cases in which the explosive device detonated, the work of the investigator is complicated considerably. The duties of the crime scene investigator are basically the same as outlined in Chapter 3; however, the investigator will have an additional consideration: safety will be a major area of concern. The scene of a bombing is generally very unsafe. The structure of the building where the bomb exploded may be seriously weakened and can collapse. Other unexploded devices may still be in the area. Hazards such as broken gas mains and downed electrical lines are potential safety problems. Securing the crime scene is another problem. Unlike most crime scenes, bomb scenes frequently attract a large number of people such as police, fire department personnel, medical and ambulance personnel, utility companies' personnel, property owners, the press, and sightseers. One

[3] The U.S. Department of Justice, National Institute of Justice, publishes *Guide to Explosion and Bombing Scene Investigation*, available on the web at: http://www.ncjrs.org/pdffiles1/nij/181869.pdf.

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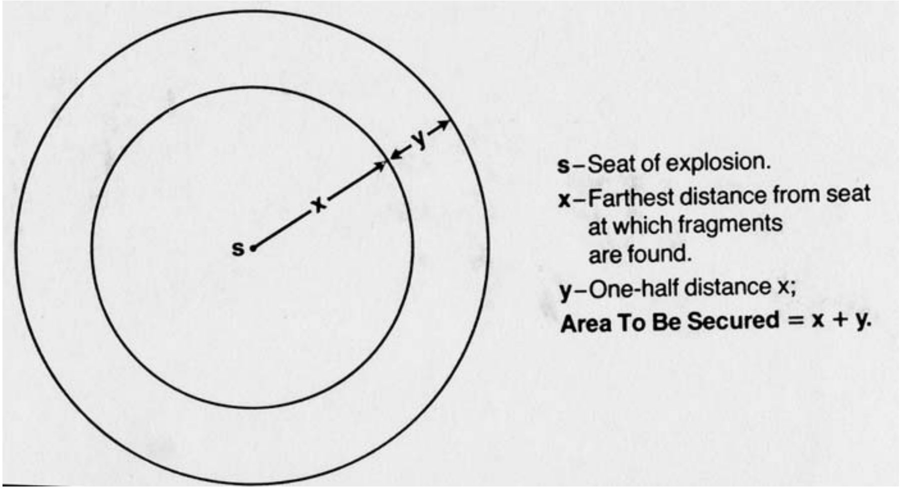

Figure 11.15 If the explosion takes place in an open space, the area in which the fragments are found and a surrounding buffer zone should be secured. *(U.S. Department of Justice.)*

of the first orders of business must be to coordinate the activities of the large number of people likely to be present and to remove individuals who are not needed.

Because of the nature of the crime, bomb scenes frequently contain a certain amount of confusion. It is necessary to restore order and control to the situation quickly to enable the investigator to accomplish the task of processing the scene. The first officers to arrive at the scene of a bombing will be concerned with emergency and safety-related activities such as rescue, evacuation, and assisting fire department personnel if required. Once the emergency phase is complete, efforts should be made to secure the crime scene and begin developing information on the circumstances of the case. Witnesses and victims should be interviewed and as much information as possible about what happened should be gathered.

Because of the number of persons present at the scene and the likelihood of several different investigative agencies being involved in the investigation, it is useful to set up a team to coordinate and control the investigation. Such a unit can act as a clearing house of information so that all information gathered from the investigative process can be integrated and studied.

Investigation of the actual scene of the bombing is a time-consuming task requiring a considerable amount of physical effort and attention to minute pieces of physical evidence. It is also dirty work requiring the investigator to sift through large quantities of debris to locate items of evidence. It is useful to have proper equipment to go through the scene. Coveralls, gloves, hard hats, goggles, work shoes, and other such items are useful for the investigator. Hand tools such as shovels, rakes, brooms, a heavy-duty magnet, and cutting tools are useful. Sifting screens of various sizes are needed for going through the debris. Wheelbarrows, trash cans to collect debris, portable lighting, ladders, and the like may be required as well.

A leader should be immediately designated to be responsible for processing and directing the bomb scene investigation. The leader also serves as a link between those coordinating the overall investigation and the crime scene investigation. The extent of the crime scene must be identified. The seat of the explosion can be a focal point and the location

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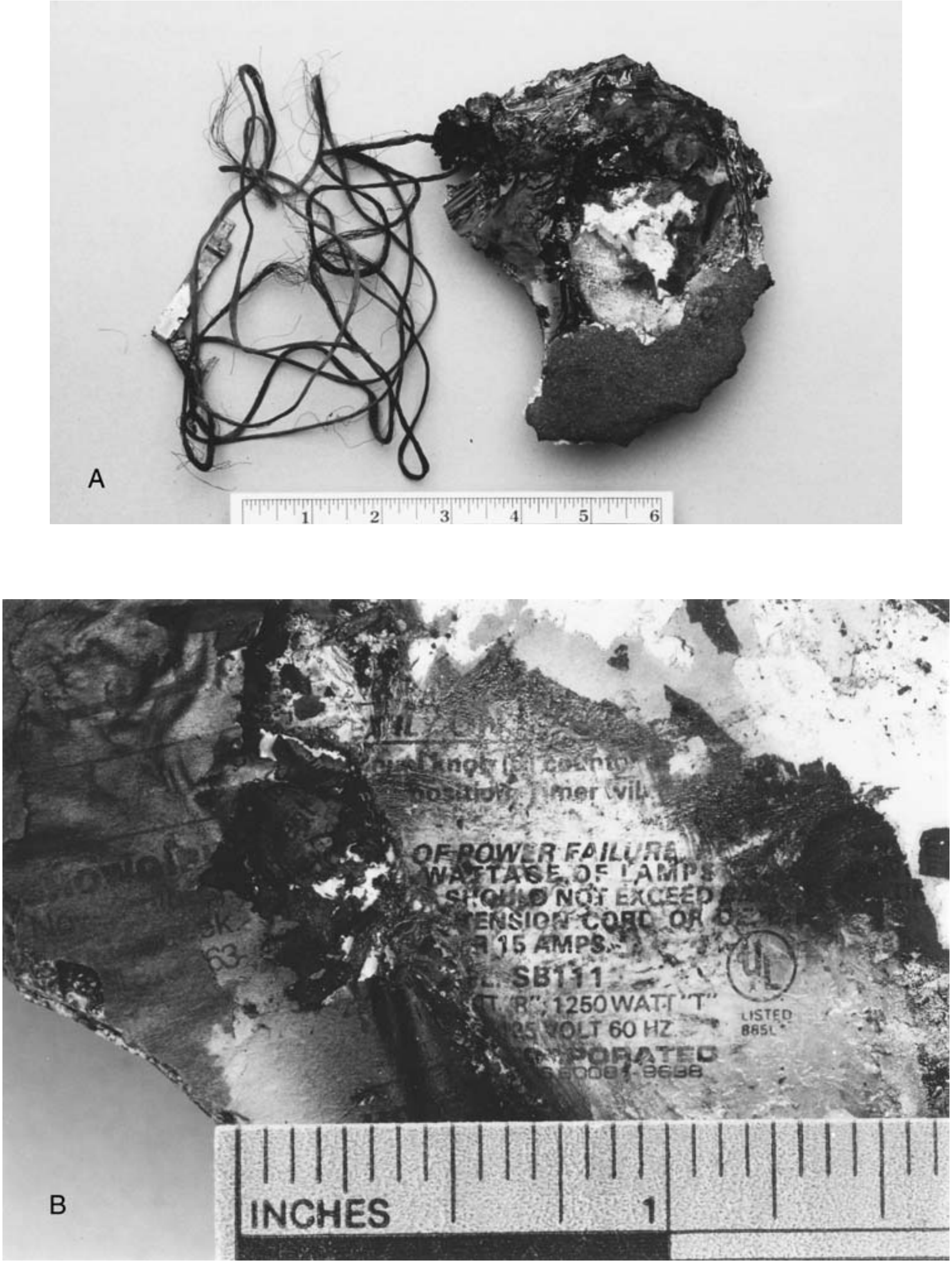

Figure 11.16 (A color version of this figure follows page 256.) A melted electrical timer device (A) and a close-up (B) showing a portion of a label believed to have been used in an arson case. The example of the intact timer (C) was used in the reconstruction of the device. *(Los Angeles County Sheriff's Department.)*

furthest from the seat where fragments from the explosion are located will define the outer perimeter of the scene. A buffer area equal to approximately half the distance from the seat to the furthest point should be added. This represents the total area that should be secured and searched (Figure 11.15).

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Figure 11.16 (continued)

The bomb scene should be recorded. This may be accomplished in the standard way by means of photography and sketches. If the capabilities exist, the scene may be videotaped. If needed, aerial photographs should be taken. Photographing, measuring, and sketching the crime scene may be done while the scene is searched.

Collecting physical evidence at the scene consists of the search for and recovery of items that may lead to information about the nature and type of explosive and the identity of the suspect. A search for the fusing mechanism of the bomb should be made. Items such as timing mechanisms, batteries, pieces of wire, safety fuses, blasting cap debris, and the like may yield information about the way in which the bomb was set to detonate. The scene should be searched for evidence to determine the type of explosive used. The seat of the explosion should be carefully examined for unexploded material and packaging material that may indicate the type of explosive used. If a portion of the container that held the device is found, laboratory tests may indicate the type of explosive. Similarly, the extent of damage to the container, for example, a pipe bomb, can indicate whether the explosive was a low-order or high explosive. In general, large fragments of a pipe bomb indicate a low explosive such as black powder, while small fragments indicate a high explosive.

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Figure 11.17 On opening a small parcel delivered to his home, a man was killed when a 2-m length of detonating cord wrapped tightly inside a food can exploded. A detailed examination of the bomb scene located a large amount of debris in which metal pieces from the rim of the food can were found. The investigator observed marks about 1 mm in diameter and opined that they were made by the feeder wheel of a can opener. After a detailed study to prove that tool marks from can opener feeder wheels left marks on can rims that were individual, the investigator was able to prove that the suspect's can opener made the marks found on the can at the scene of the explosion. *(South Australian Police, Adelaide, South Australia.)*

The package that contained the explosive device may contain evidence to lead the investigator to a suspect. Fingerprints, names, addresses, and postmarks may be important information in the investigation. The investigator should not forget to search for other evidence besides the bomb debris. Items such as fingerprints, tire tracks, tool marks, and the like are valuable and must not be overlooked.

If a suspect is apprehended shortly after the explosion, the clothing should be collected and submitted to the laboratory for examination for trace evidence and explosive debris. The suspect's hands should be swabbed with cotton applicators moistened with acetone to test them for certain explosives. If the suspect's vehicle is located, it too should be

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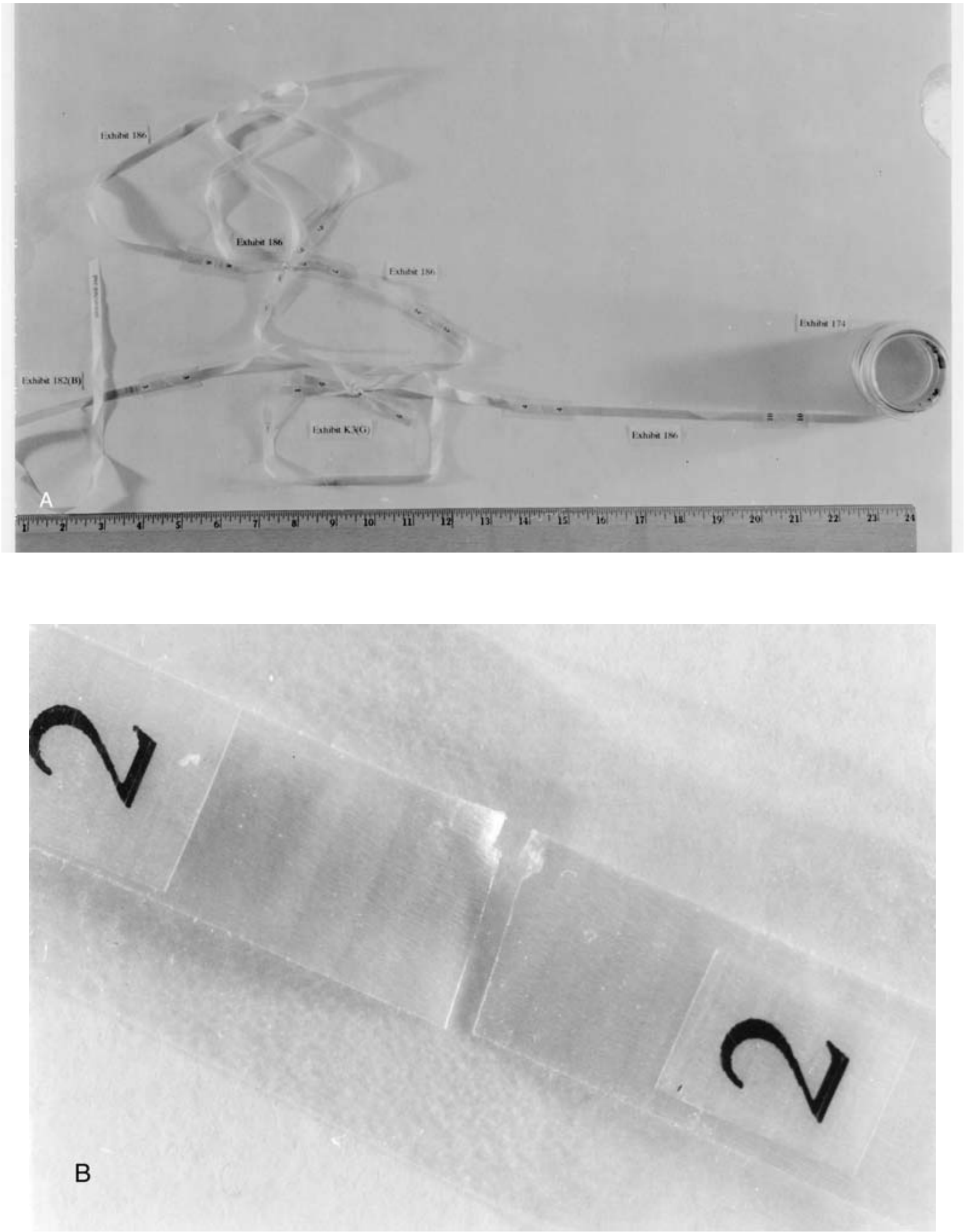

Figure 11.18 Ribbon used to wrap the package (A) and matching ends (B). (*U.S. Postal Service.*)

carefully searched for tools, trace evidence, explosive residue, and materials that may have been used in the crime (Figure 11.18).

All evidence should be photographed where it was found, measured, and located on a crime scene sketch prior to being moved. The investigator should remember also to search high areas such as trees, roofs, ledges of buildings, and other places that may contain pieces of the exploded device.

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Because of the large number of persons involved with the bomb scene search and the amount of evidence collected, it is helpful to keep an evidence log to detail each item of evidence collected, including the date, time, and name of the person collecting the material. The use of a log facilitates establishing a chain of evidence and makes inventory of all the evidence somewhat easier.

The crime laboratory plays an important role in bomb scene investigation. Often the nature of the explosive used and information about the type of mechanism used to detonate it cannot be determined in the field. The laboratory will carefully and systematically examine all the items of evidence and attempt to answer some of the questions required by the investigator to assist in the solution of the case.

Bomb and arson scene investigations require much time and patience, and crime scene investigating officer's extreme attention to detail. The officer's willingness to carefully and painstakingly go through large amounts of debris and rubble in an attempt to locate pertinent physical evidence may result in a successful conclusion to the case.

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11 Arson and Explosives

Arson is defined as the willful and malicious burning of another's property or the burning of one's own property for some illegal purpose such as defrauding an insurer. As a crime, arson ranks only behind traffic-related incidents in the highest losses of life and property. In dollars, property losses due to arson can be placed in the billions of dollars annually.

Arson investigation[1] requires a considerable amount of care, attention to detail, and skill on the part of the investigator. Arson scenes present a host of problems that are uncommon to most other crime scene investigations. In most criminal investigations, once the crime has been committed and the police notified, the scene may be secured in relatively the same condition in which it was found. This is anything but the case in fire investigation. By the time the arson investigator arrives on the scene, numerous individuals including fire fighters, supervisory personnel, onlookers, and possibly the owner of the property will have visited the crime scene. The preservation of the crime scene is frequently the last things to be considered by firefighters when "knocking down" a blaze.

The issue of criminal intent is another major difference in arson investigations compared with other investigations. With most other crimes, the investigator frequently knows on arrival or shortly thereafter that a crime has been committed. With arson cases, determining whether a fire was set accidentally or intentionally may require considerably more investigation.

Arson and explosion crime scenes are unique in the amount of destruction and devastation present. An item that normally is identifiable as important evidence in an investigation can be totally or partially destroyed by the fire or by fire fighters. In spite of the difficulties inherent in arson investigation, a careful and thorough search of the fire scene can produce much useful information.

A number of motives are frequently associated with arson. Probably the most common motives are concealment of other crimes and defrauding an insurance company. A fire investigator frequently finds that the fire was set to cover up another crime such as murder, burglary, embezzlement, or fraud. The attempt in these cases is to destroy records and evidence of the crime that could make identifying the suspect or the victim of a murder impossible. In insurance fraud cases the suspect may have suffered a business reversal or

[1] The U.S. Department of Justice, National Institute of Justice, publishes *Fire and Arson Scene Evidence: A Guide for Public Safety Personnel*, available on the web at: http://www.ncjrs.org/pdffiles1/nij/181584.pdf; The International Association of Arson Investigators has a web page at http://www.firearson.com/: The National Fire Protection Association is another important association. Its web site is located at http://www.nfpa.org/; The National Association of Fire Investigators has a web site at http://www.nafi.org/.

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Figure 11.1 The scene of an arson fire at Universal Studios in Los Angeles showing the clock tower from the movie *Back to the Future.* (*Los Angeles County Sheriff's Department.*)

be heavily in debt. The fire is set to appear accidental with the intent of filing a false insurance claim. Other motives such as malicious mischief caused by juveniles, revenge, extortion, sabotage, terrorist acts, and pyromania all represent potential reasons for setting fires.

The arson investigator should focus the investigation to answer several questions:

1. **Where did the fire originate?** Information can be obtained by questioning fire fighters about the location of hot spots, in which direction the fire was moving, how fast, etc. The most information will be gained by going through the scene and noting what areas suffered the most fire damage and exposure to heat. The origin of the fire is evidenced by the depth of char on burned items, degree of destruction, spalling, metal or glass bent or melted by exposure to heat for a longer time than other areas, and burning or heat fading of paint. Be alert to multiple sources or the entire structure as the origin.
2. **How was the fire started?** The investigator should look for faulty electrical wiring, the presence of igniters, matches, ignitable material, kindling, and other means of starting the fire. Ignitable fluids will run into cracks and under objects on the floor and cause burning in locations that would not normally burn. They will also char deeper in areas where they were located, sometimes burning through the floor.
3. **Was the cause of the fire an accident or was it intentionally set?** This is the key issue in determining whether the fire was arson. Evidence such as breaking into and entering the building, presence of ignitable fluids, and multiple points of origin may indicate a maliciously set fire.

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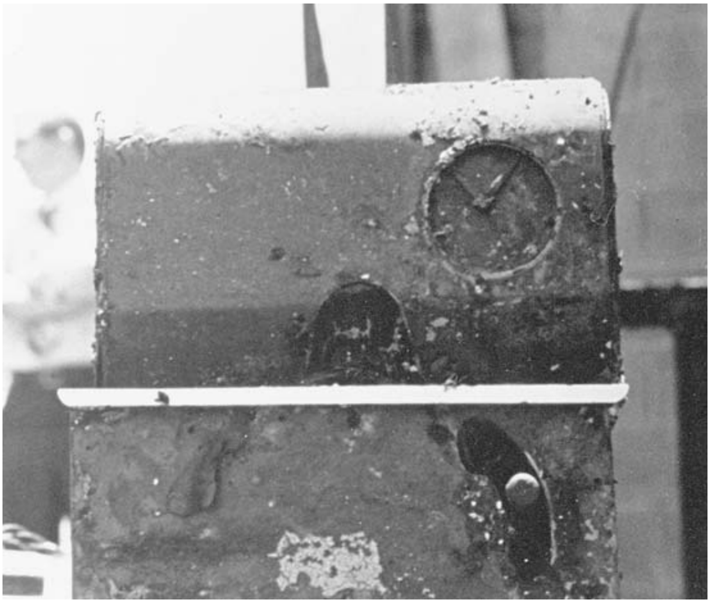

Figure 11.2 A burned-out electrical timer device located at a fire scene can give the approximate time at which the power went out as a result of the fire. *(Los Angeles County Sheriff's Department.)*

Physical Evidence

The presence of ignitable fluids is the most commonly sought physical evidence in arson investigation. Even in cases in which fire damage was particularly extensive or the scene was completely wetted down, there is still a good probability of detecting ignitable fluids. The search for ignitable fluids should be concentrated at the point where the fire started. If charred rags or carpeting is noted, these should be collected and sent to the laboratory. Wood flooring, furniture, and carpet padding into which gasoline or kerosene may have been absorbed should also be collected as well as empty containers or broken glass jars found at the scene.

Ignitable fluids are highly volatile and evaporate easily. For this reason, appropriate packaging must be used to preserve these items for laboratory analysis. Packaging evidence in paper or plastic bags or containers will not preserve it. Such packages allow volatile liquids to dissipate completely. The best manner of packaging these items is in clean metal paint cans. The items should be placed into the cans, which should then be tightly sealed with metal lids. An alternative method of preserving evidence is to use glass jars with metal screw-cap lids. Metal and glass containers retain small amounts of liquids and vapors that can be analyzed by the crime laboratory. The quantity of material needed for chemical analysis of an ignitable substance is extremely small. Laboratory instruments are capable of readily identifying ignitable liquids in quantities of less than a fraction of a drop. In fact, if an odor of an ignitable liquid can be detected, there is a good chance that a forensic lab can identify the source.

Laboratory analysis can differentiate among the many types of accelerants used in arson cases. The common types are gasoline, kerosene, charcoal lighter fluid, paint thinner,

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Figure 11.3 A melted aluminum awning indicates the approximate temperature of the fire. Aluminum melts at 660.2°C. *(Los Angeles County Sheriff's Department.)*

and turpentine. In some cases the dyes contained in gasoline can be used as a means of comparison with known samples. Highly sophisticated scientific instrumentation at some laboratories may be able to differentiate brands of gasoline.

A careful search of all entrances and windows should be made to determine whether the building had been forcefully entered. If tool marks are observed, the area should be cut out or an impression made and submitted to the laboratory. Also, samples of building materials such as glass, paint, plaster, stucco, wallboard, cement, etc. that may have been deposited on the suspect's clothing should be collected for purposes of control or known samples. All evidence must be properly marked for identification and packaged properly. In some instances, an apparent forced entry might have been used to cover up arson, so such things as the side from which a window was broken, screen cut, etc., should be checked.

The investigation should include the search for igniting materials; burned matches and matchbooks should be collected. Burned matches, in some cases, can be physically fitted into a matchbook found on a suspect and matchbooks can be chemically processed for fingerprints. Occasionally, pieces of a timing device used to delay the ignition of a fire may be discovered.

Other types of igniters such as candles, black powder, smokeless powder, sodium and water, electrical devices, and similar items should be noted and collected. It is important that the manner in which the fire started be established. This determines the M.O. (*modus operandi*) of the arsonist.

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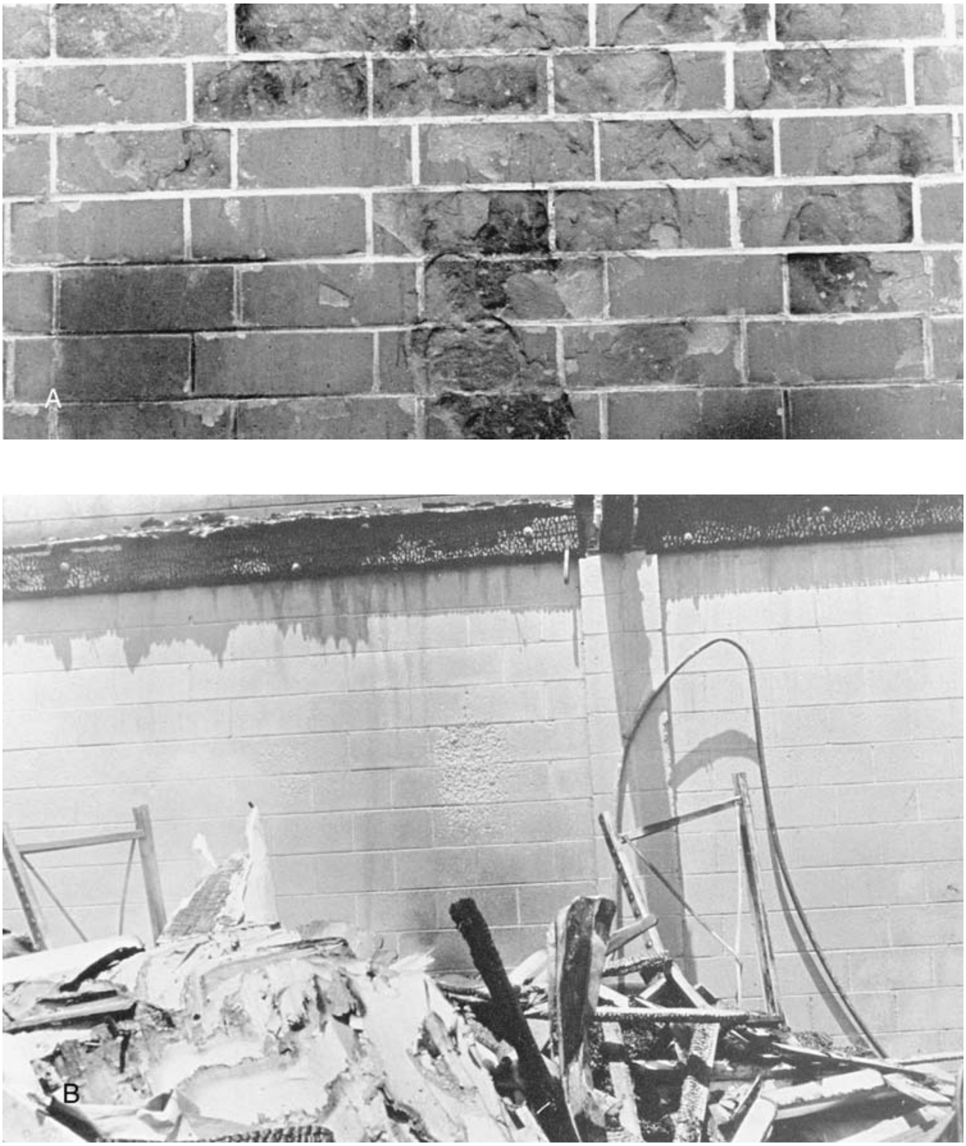

Figure 11.4 These photographs depict (A) chipping or splintering, commonly known as spalling, on a brick wall caused by a hot spot at the scene and (B) another example of spalling on a cinder block wall. *(Los Angeles County Sheriff's Department.)*

If the scene of the arson is a business establishment, the investigator may notice that file cabinets have been pulled open and papers strewn about. Burned papers should be carefully collected and placed into cardboard boxes, handling them as little as possible. Burned paper may be examined at the laboratory and useful information can be determined. For example, it may be very beneficial to know what files were burned or are missing.

If the fire was started outdoors, the area of the origin of the fire should be examined. Soil from that area should be collected and tested for the presence of ignitable materials. To accomplish this, a clean, gallon paint can should be filled with soil, sealed, and submitted to the laboratory along with a control sample.

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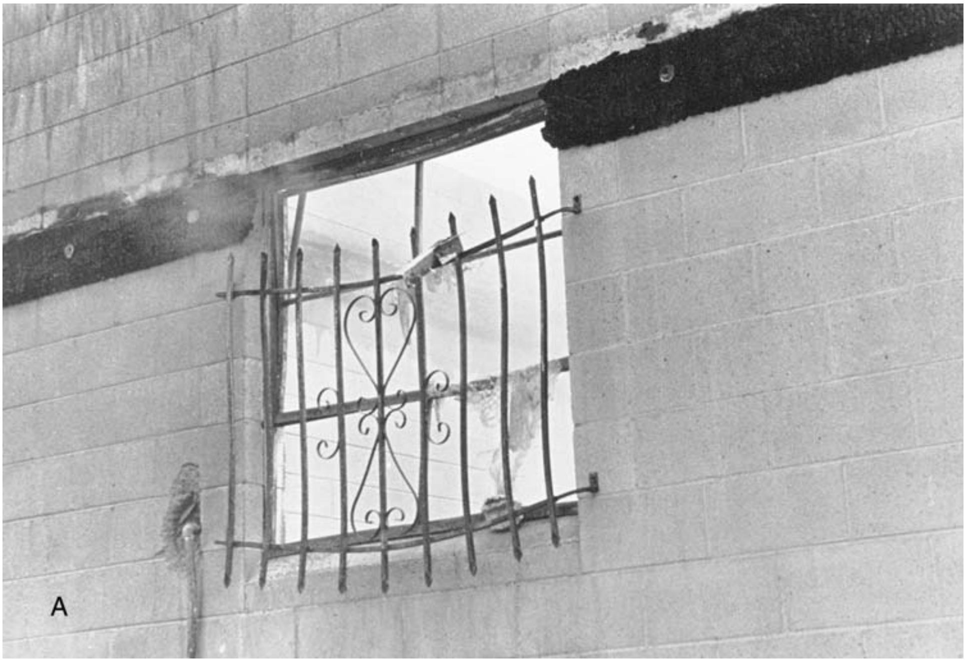

Figure 11.5 (A) Melted safety glass may indicate exposure to heat for a period of time, thereby suggesting a point of origin of the fire. (B) Deformed pipe as a result of the heat of the fire. (C) Typical appearance of burned lumber, referred to as "alligatoring," indicating the surface texture of the burned wood. *(Los Angeles County Sheriff's Department.)*

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Figure 11.5 (continued)

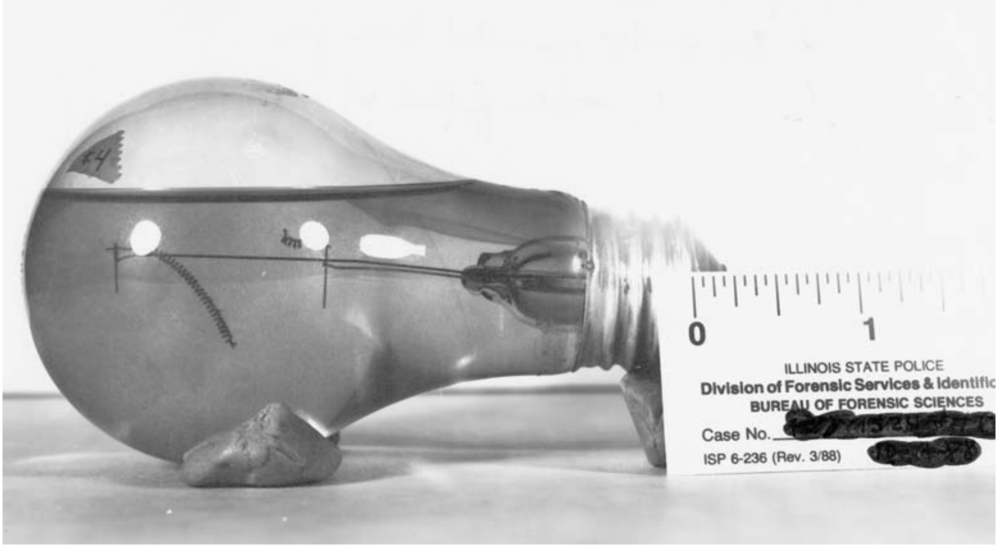

Figure 11.6 This incendiary device, a light bulb with a small hole drilled into the base, filled with medium petroleum distillate, and sealed with a putty-like material, was found in a light socket connected to a timer in a house under construction. The device probably would not have worked because too much liquid was in the bulb, which covered the filament. *(Illinois State Police, Bureau of Forensic Sciences.)*

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Figure 11.7 A portion of a "Molotov cocktail" with a shot shell. *(Illinois State Police, Bureau of Forensic Sciences.)*

Any items left at the scene by the arsonist should be preserved. Traces such as pieces of clothing, hair, blood, tools, broken tools, etc. may prove to be important as a means of establishing identity of the suspect.

When a suspect is apprehended, a careful search of his property should be made to determine whether anything can be tied to the crime or the crime scene. Any accelerants such as gasoline or kerosene should be packaged and submitted to the laboratory for comparison with solvents detected at the scene of the arson. Similarly, objects such as tools, matches, matchbooks, incendiary devices, and the like should be collected. The suspect's clothing and shoes should be collected, packaged, and sent to the laboratory for examination for the presence of these materials.

The suspect's vehicle should be inspected for the presence of material removed from or transported to the scene of the arson. Any search of the suspect's vehicle or residence may require a search warrant. The local prosecutor should be contacted if there is any question.

In cases in which a dead body is discovered in the investigation, a determination of the cause of death is necessary to ascertain whether the victim died as a result of the fire or the fire was set in order to conceal the killing. The pathologist will be able to determine at the time of the autopsy whether the person died of smoke inhalation or was dead prior to the fire.

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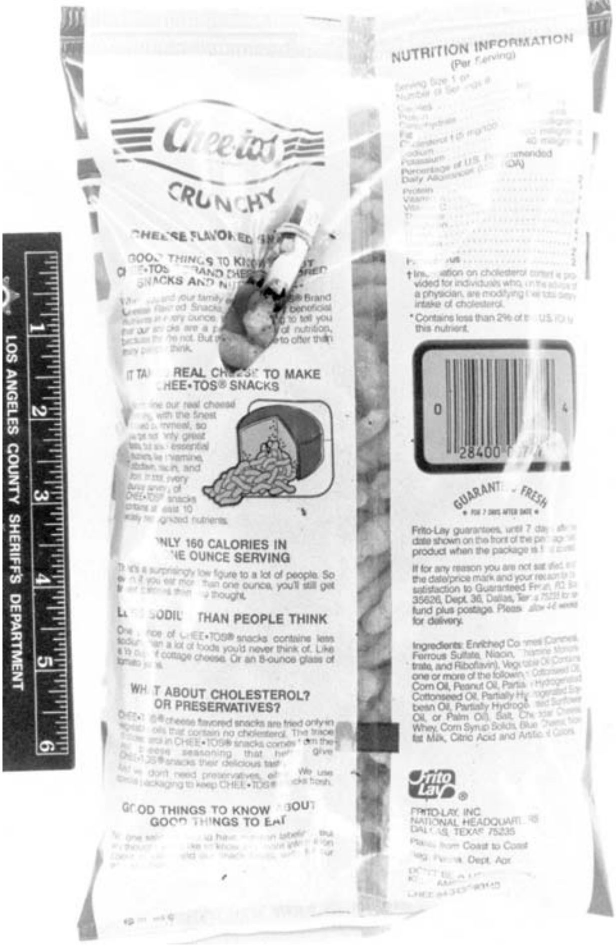

Figure 11.8 An improvised incendiary device consisting of a cigarette and matches can produce sufficient heat to cause the contents of the bag to burn. *(Los Angeles County Sheriff's Department.)*

Explosives[2]

Explosives are useful tools by which people have accomplished some remarkable engineering feats. However, like many other things, explosives are used for criminal ends as well. Murder, burglary, extortion, terrorist activities, and similar activities involving explosives require the attention of the investigator. Bomb scene investigation is frequently treated as a specialty within some police agencies and is often associated with arson investigation. Although certain aspects of crime scene investigation of bombings differ from a common crime scene, the basics remain the same.

[2] The International Association of Bomb Technicians and Investigators has its web site at http://www.iabti.com/.

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Figure 11.9 Examples of boosters, blasting caps, and dynamite. *(Los Angeles County Sheriff's Department.)*

In broad terms, an explosive is a material capable of rapid conversion from either a solid or a liquid to a gas with resultant heat, pressure, and loud noise. Many chemicals, alone or in combination, possess the necessary properties for an explosive. Except for chemical compounds classed as explosives, the rest usually come to the investigator's attention only as the result of some accident. In such cases, consultation with a forensic chemist or criminalist will provide a satisfactory explanation for the explosion.

Explosives can be classed into two broad groups: low explosives and high explosives. High explosives consist of primary and secondary explosives; low explosives burn rather than explode. Damage by low explosives is caused by the force exerted by the rapid expansion of gases formed by burning. These types of explosives must be confined to explode. High explosives, in general, are detonated by shock and have much higher detonation velocities; they need not be confined to explode.

Low Explosives

Black powder is the most common type of low explosive. It is a mixture of potassium or sodium nitrate, sulfur, and charcoal. There has been wide variation in the formulation of this mixture over the years. Black powder is sensitive to heat, impact, friction, and sparks. When placed into a confined area, such as a pipe bomb, black powder can be a destructive explosive. Detonation can easily be accomplished by means of a safety fuse. If an unexploded pipe bomb is encountered, it is very important to exercise extreme care in opening

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Figure 11.10 Debris from a pipe bomb packed with a low-order explosive. *(Los Angeles County Sheriff's Department.)*

the device because it can be set off by friction. One of the most common uses of black powder is in the manufacture of safety fuses.

Safety fuses are used to initiate explosives nonelectrically; they are generally composed of black power with a protective covering of cotton yarn or jute followed by an asphalt layer for water resistance. The asphalt covering is then covered with an insulating material such as a polyethylene plastic covering or a wax-impregnated yarn jacket. The color of the fuse is generally white, black, or orange.

Safety fuses should normally burn at a definite rate of speed, but may burn faster or slower depending on several factors such as age, handling, altitude, and humidity. Usually, they burn at about 30 to 40 seconds per foot; however, the actual rate should be determined by testing a given length (Figure 11.11).

Smokeless powder is another low explosive encountered in bomb investigations. It is mainly used for small arms ammunition but is frequently used in pipe bombs. Two types of smokeless powder are marketed: single and double base. Single-base smokeless powder consists of nitrocellulose, while double-base is composed of nitrocellulose and nitroglycerine. Although smokeless powder is not as sensitive to friction as black powder, it should be handled with the same amount of care.

High Explosives

Primary explosives detonate when subjected to heat or shock. They are typically used as initiators of high explosives, to detonate main charges, and in blasting caps and firearm primers. For this type of explosive, the major interest in bomb investigation is in blasting

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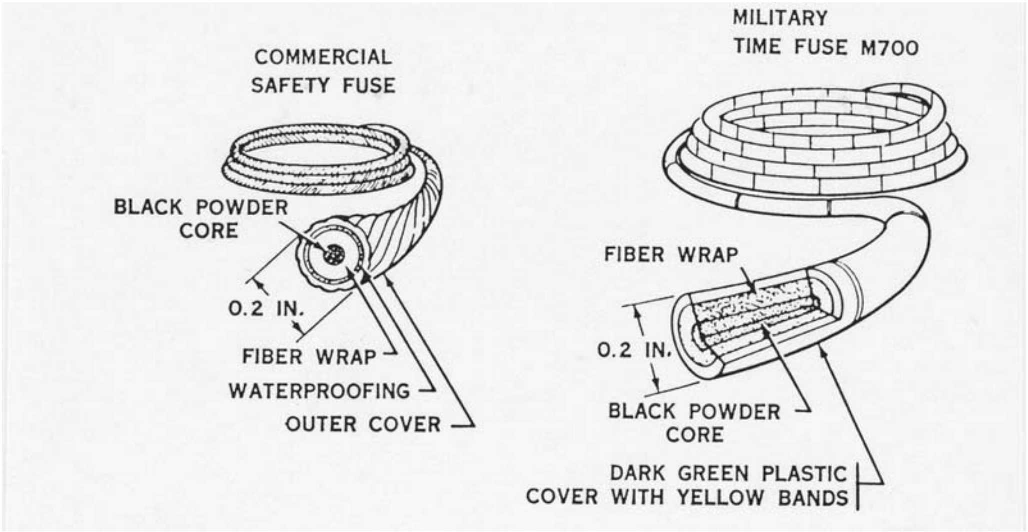

Figure 11.11 Safety fuses. *(U.S. Department of Justice.)*

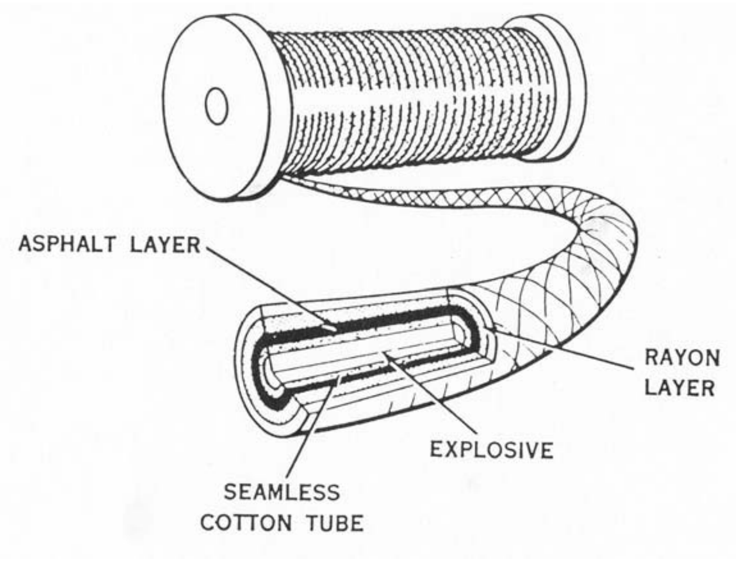

Figure 11.12 Detonating cord. *(U.S. Department of Justice.)*

caps. *Blasting caps* are of two types: electric and nonelectric. They are small explosive devices, about 1/4 inch in diameter and from 1 to 3 inches in length. The case may be made of aluminum, copper, or bronze. The electric blasting caps have colored wires extending from them.

Secondary explosives detonate by shock from a suitable primary explosive. Their detonation velocities range from 3300 feet per second in the case of ammonium nitrate to 29,900 feet per second in the case of HMX. Typically, high explosives are used to shatter or destroy objects.

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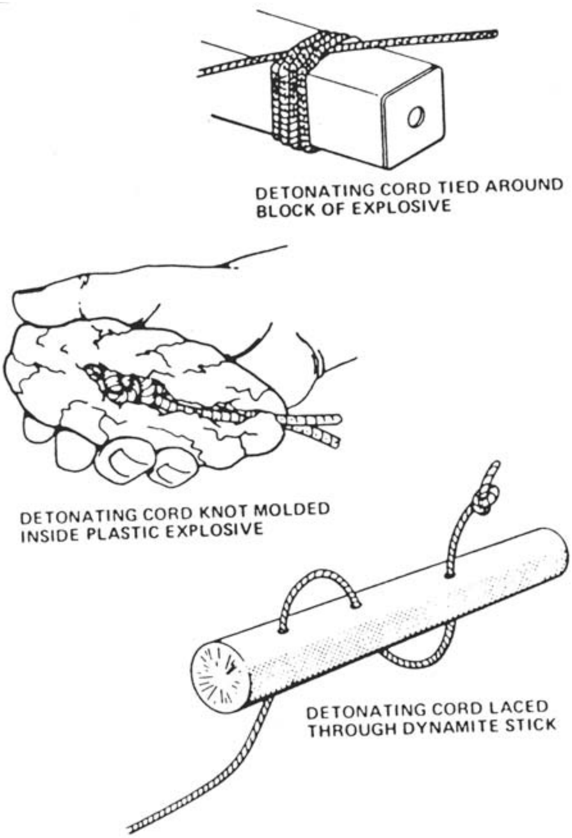

Figure 11.13 Examples of use of detonating cord to prime explosives charges. *(U.S. Department of Justice.)*

Detonating cord is a cord-like explosive, similar in appearance to a safety fuse. It contains a central core of RDX or PETN covered with cotton or other textile, followed by a waterproof material or plastic covering. The cord detonates at velocities from 18,000 to 23,000 feet per second. It is very insensitive to shock and heat and presents no special problems in handling. Detonating cord is used to set off charges of high explosives much in the same way as a safety fuse is used to set off multiple pyrotechnic devices. The detonating cord may be inserted, tied, or knotted inside the high explosive to initiate detonation. Detonating cord is used to set off simultaneous charges and is detonated by means of a blasting cap (Figures 11.12 and 11.13).

Boosters or primer explosives are used to detonate very insensitive high explosives. The booster consists of a secondary explosive such as RDX, PETN, tetryl, or pentolite and is detonated by means of a blasting cap. Boosters are usually cylindrical in shape with a small opening to permit insertion of a blasting cap.

A large number of high explosives are used commercially and by the military. Next, some of the more common ones encountered in law enforcement work are detailed; however, the list is not intended to cover all of the many types.

Nitroglycerine was first developed in 1847, but it was not until 1867 that Alfred Nobel developed a method to desensitize this explosive sufficiently so that it could be used

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commercially. Nobel's invention, *dynamite*, was a mixture of nitroglycerine and diatomaceous earth. Today, dynamite contains EGDN (ethyleneglycoldinitrate) in addition to other materials used to desensitize the nitroglycerine. Inert materials such as wood pulp or sawdust, cornmeal, sodium nitrate, and many other materials are found in dynamite, which is usually packaged in cylindrical sticks and wrapped in waxed paper. The sticks come in a variety of sizes; the most common is 1 1/8 to 1 1/2 inches in diameter and 8 inches in length. Other sizes may be as large as 12 inches in diameter and 4 to 36 inches long. There are four basic types of dynamite in use today: straight dynamite, ammonia dynamite, gelatin dynamite, and ammonia–gelatin dynamite.

Straight dynamite — manufactured in strengths of 15 to 60% by weight of nitroglycerine. The nitroglycerine is generally absorbed onto a material such as wood pulp or ground meal (such as cornmeal, cornstarch, or the like). Dynamite has a sweet, pungent odor and frequently may cause headaches. Straight dynamite has an oily, slightly moist appearance and resembles a mixture of oil, sawdust, and clay. In older sticks of dynamite, the outer wrapper may often look oil-stained from the nitroglycerine seeping out of the mixture. Police should treat such dynamite with extreme caution because it is in a highly unstable form.

Ammonia dynamite — some of the nitroglycerine is replaced with ammonium nitrate. Ammonia dynamite is less sensitive to shock than straight dynamite and has less of a shattering effect, but is more suitable for "pushing." The color of ammonia dynamite is light brown, compared with a slight reddish tint in the case of straight dynamite.

Gelatin dynamite — a water-resistant form of dynamite manufactured by combining nitroglycerine with nitrocellulose. The resulting "gel" forms a thick, viscous liquid useful under wet conditions.

Ammonia–gelatin dynamite — a combination of the last two formulations. The addition of the ammonium nitrate is a cost-saving factor and the gelatin allows the explosive to be used in wet conditions.

Ammonium nitrate is a readily available material used as an explosive and, in a less pure form, as a fertilizer. In its pure form it is a white crystalline material but may be a light tan color in a less pure form. As an explosive it is relatively insensitive and requires a booster charge to be detonated. Because of its easy availability as a fertilizer, although less pure than explosive grade ammonium nitrate, it is readily available for use in homemade bombs. A modification of ammonium nitrate sometimes used is a mixture of ammonium nitrate and fuel oil, also known as ANFO.

Water gels or slurries are classified as either blasting agents or explosives, depending upon what they contain and whether or not they are cap-sensitive. Water gels typically have an ammonium nitrate base, a sensitizer, a thickener, and 5 to 40% water. The sensitizer may be an explosive such as TNT, nitrostarch, or smokeless powder, or it may be a nonexplosive such as sugar, fuel oil, carbon, or a powdered metal. These explosives are rapidly gaining in popularity as substitutes for dynamite. Most slurries require a primer or booster for detonation; however, some manufacturers make cap-sensitive gels.

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Blasting Agents

Blasting agents, also known as nitrocarbonitrate (NCN), are insensitive chemicals and chemical mixtures that are detonated by means of a high-explosive primer or booster. In order to be classified as a blasting agent, the material must be unable to be detonated by a No. 8 blasting cap and contain no high explosives such as TNT or nitroglycerine. Blasting agents consist largely of ammonium nitrate. ANFO is considered a blasting agent and consists of 94% ammonium nitrate and 6% fuel oil. The advantage of blasting agents is that safety regulations governing shipping and storage are considerably less severe than those applicable to high explosives.

Binary explosives are two inert, nonexplosive chemicals that, when mixed, form a cap-sensitive high explosive. The materials are either both liquids or a powder and a liquid; in their unmixed states they are very insensitive to shock or friction. One component is usually ammonium nitrate, while the other is a nonexplosive sensitizer.

Military Explosives

Sheet explosives are flexible, rubber-like sheets approximately 1/4 inch thick that can be cut with a knife. These explosives are used in commercial and military circumstances. The high explosive used is either RDX or PETN. Sheet explosives are known as Flex-X, Datasheet, or M118 Demolition Block (the latter military sheet explosives). The most common type of military explosive is *trinitrotoluene (TNT)*. Military explosives differ somewhat from commercial explosives in that they must be used in combat conditions. Typically, they must be relatively insensitive to heat, shock, friction, and bullet impact, have high destruction power (brisance), be lightweight and convenient to use, be usable under water, etc.

TNT is generally encountered in military explosives in 1/4-, 1/2-, and 1-pound blocks. The blocks have metal ends with a threaded well at one end for a blasting cap. The container is cardboard and the TNT is a light yellow to brown color although some newer formulations of TNT may be gray due to the addition of graphite.

RDX is used in the so-called *plastic explosives*. Plastic explosives contain plasticizers in addition to RDX and are easy to mold in warm temperatures.

Composition C-3, containing 77% RDX, is a yellow putty-like material that has a distinctive heavy, sweet odor. When molded, it will stain the hands and clothing. The M3 block is enclosed in glazed paper that is perforated around the middle for ease in breaking open and weighs 2 1/4 pounds. The block does not have a cap well.

Composition C-4 is replacing C-3 in military use. C-4 contains 91% RDX, is white to light brown in color, has no odor, and does not stain the hands. The M5A1 block demolition charge contains C-4 in a clear white plastic container with a threaded cap recess at each end. It weighs 2 1/2 pounds. Composition C-4 also comes in the M112 block demolition, an improvement of the M5A1 that replaces it as a standard issue. The M112 contains 1 1/4 pounds of composition C-4 with a pressure-sensitive adhesive tape on one surface, protected by a peelable paper cover. The C-4 in some blocks is colored dull gray and packed in a clear Mylar-film bag. In blocks of more recent manufacture, the C-4 is white and packed in an olive drab Mylar bag.

Military dynamite is not really dynamite, but a mixture of 75% RDX, 15% TNT, 5% SAE 10 motor oil, and 5% guar flour. It is packaged in waxed manila paper and marked

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M1, M2, or M3. Military dynamite is buff-colored granular material that crumbles easily and is slightly oily to the touch. It does not have the characteristic odor usually associated with dynamite because it contains no nitroglycerine.

The explosives discussed to this point are some of the more common ones encountered and represent explosives available through commercial and military sources. The explosives industry, however, is a rapidly changing one and the reader should understand this when studying the subject. It is suggested that the investigator consult explosive manufacturers, law enforcement agencies that routinely deal with explosive cases, and forensic science laboratories for the latest information on the subject.

Homemade Explosives

If commercial or military explosives are not available, it is not particularly difficult for an individual to improvise from a large number of chemicals that, when mixed together, can produce highly destructive explosive devices. The investigator should recognize at least some of the more common materials that often find their way into homemade explosive devices (Figure 11.14).

Materials such as starch, flour, sugar, cellulose, etc. can be treated to become effective explosives. Powder from small arms ammunition and from firecrackers, match heads, and ammonium nitrate from fertilizers can be used in explosive devices. To detonate an improvised explosive device, several methods are available:

- **Blasting caps.** Caps, especially electrical blasting caps, lend themselves to homemade bombs. Such devices may be set off by a timing mechanism, by movement, by wiring into an automobile ignition system, etc.
- **Percussion primers.** Primers from shotgun, rifle, or pistol ammunition are sometimes used to detonate explosives that are heat sensitive.
- **Flashbulbs.** Flashbulbs may be used to ignite heat-sensitive explosives such as black powder. If the bulb is placed in contact with the explosive, the resulting heat from the flashbulb will ignite materials such as black powder, smokeless powder, incendiary mixtures, etc. As mentioned earlier, because of its relative ease to manufacture, black powder is frequently used in homemade bombs.
- **Match heads.** Match heads are frequently found confined inside pipe bombs. They are sensitive to heat, friction, and shock and when confined in this type of device can produce an effective explosion.
- **Smokeless powder.** Powder from ammunition or for reloading purposes is frequently used as the main charge in pipe bombs.
- **Ammonium nitrate fertilizer.** Ammonium nitrate mixed with fuel oil and an appropriate booster makes an extremely effective homemade explosives device.
- **Potassium or sodium chlorate.** These compounds and sugar are used as incendiary and explosive materials.

The list of possible chemicals for improvised explosives is endless. Officers who come upon locations with large numbers of chemicals such as nitrates, chlorates, perchlorates,

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Figure 11.14 (A) Debris from a homemade explosives device with a timing mechanism. (B) An example of an unexploded homemade device with a timer. *(Los Angeles County Sheriff's Department.)*

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nitric acid, aluminum powder, magnesium, sodium, sulfur, charcoal, sugar, and sulfuric acid, to name just a few, should be aware that the location may be one where homemade explosives are made.

Bomb Scene Investigation[3]

Physical evidence in bombing cases is useful in answering many questions. Some of the questions that the investigator will be interested in answering are:

- What materials were used to make the explosive device?
- What was the level of skill or expertise of the suspect?
- What was the target of the bomb?
- Was the explosion accidental or was there criminal intent?
- Where was the bomb made?
- Where was the bomb placed?
- Where did the suspect obtain the material to construct the device?
- Who was the victim or intended victim?
- Who made the bomb and who placed it?
- How was the bomb detonated?

The nature of the target, whether or not the bomb exploded, the extent of damage, the location of the incident, and weather conditions are some of the factors that influence the action to be taken by the investigator. If a bomb is found that has not exploded, it is necessary to call in a bomb technician to render the device safe. The first priority of the technician is to disarm the bomb safely. If possible, the investigator should photograph the bomb prior to moving it and have the bomb technician note any changes made in the device when dismantling it. If the bomb must be exploded to be disarmed, it should be done in such a way as to avoid total destruction of the device.

The scene should be thoroughly searched for evidence that may have been left by the suspect. Collection of evidence should include a search for a forced entry and accompanying tool marks, fingerprints, footprints, and any other traces that may help link a suspect to the crime scene.

In cases in which the explosive device detonated, the work of the investigator is complicated considerably. The duties of the crime scene investigator are basically the same as outlined in Chapter 3; however, the investigator will have an additional consideration: safety will be a major area of concern. The scene of a bombing is generally very unsafe. The structure of the building where the bomb exploded may be seriously weakened and can collapse. Other unexploded devices may still be in the area. Hazards such as broken gas mains and downed electrical lines are potential safety problems. Securing the crime scene is another problem. Unlike most crime scenes, bomb scenes frequently attract a large number of people such as police, fire department personnel, medical and ambulance personnel, utility companies' personnel, property owners, the press, and sightseers. One

[3] The U.S. Department of Justice, National Institute of Justice, publishes *Guide to Explosion and Bombing Scene Investigation*, available on the web at: http://www.ncjrs.org/pdffiles1/nij/181869.pdf.

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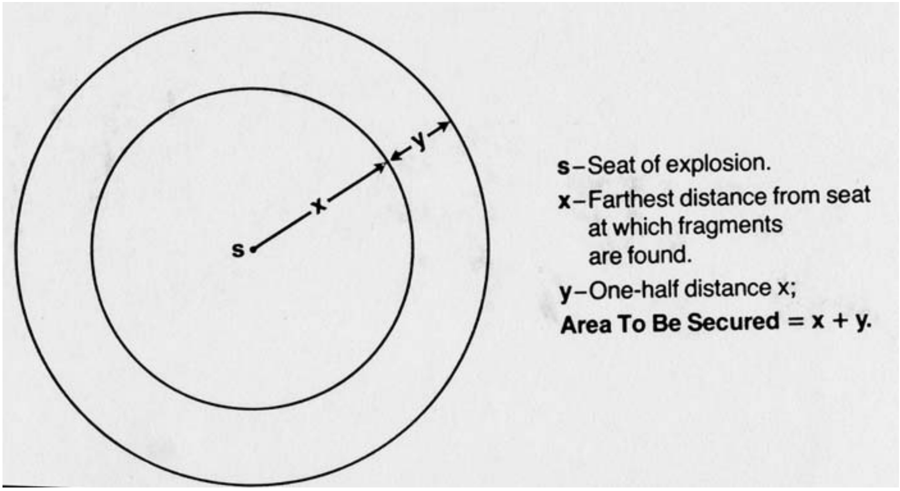

Figure 11.15 If the explosion takes place in an open space, the area in which the fragments are found and a surrounding buffer zone should be secured. *(U.S. Department of Justice.)*

of the first orders of business must be to coordinate the activities of the large number of people likely to be present and to remove individuals who are not needed.

Because of the nature of the crime, bomb scenes frequently contain a certain amount of confusion. It is necessary to restore order and control to the situation quickly to enable the investigator to accomplish the task of processing the scene. The first officers to arrive at the scene of a bombing will be concerned with emergency and safety-related activities such as rescue, evacuation, and assisting fire department personnel if required. Once the emergency phase is complete, efforts should be made to secure the crime scene and begin developing information on the circumstances of the case. Witnesses and victims should be interviewed and as much information as possible about what happened should be gathered.

Because of the number of persons present at the scene and the likelihood of several different investigative agencies being involved in the investigation, it is useful to set up a team to coordinate and control the investigation. Such a unit can act as a clearing house of information so that all information gathered from the investigative process can be integrated and studied.

Investigation of the actual scene of the bombing is a time-consuming task requiring a considerable amount of physical effort and attention to minute pieces of physical evidence. It is also dirty work requiring the investigator to sift through large quantities of debris to locate items of evidence. It is useful to have proper equipment to go through the scene. Coveralls, gloves, hard hats, goggles, work shoes, and other such items are useful for the investigator. Hand tools such as shovels, rakes, brooms, a heavy-duty magnet, and cutting tools are useful. Sifting screens of various sizes are needed for going through the debris. Wheelbarrows, trash cans to collect debris, portable lighting, ladders, and the like may be required as well.

A leader should be immediately designated to be responsible for processing and directing the bomb scene investigation. The leader also serves as a link between those coordinating the overall investigation and the crime scene investigation. The extent of the crime scene must be identified. The seat of the explosion can be a focal point and the location

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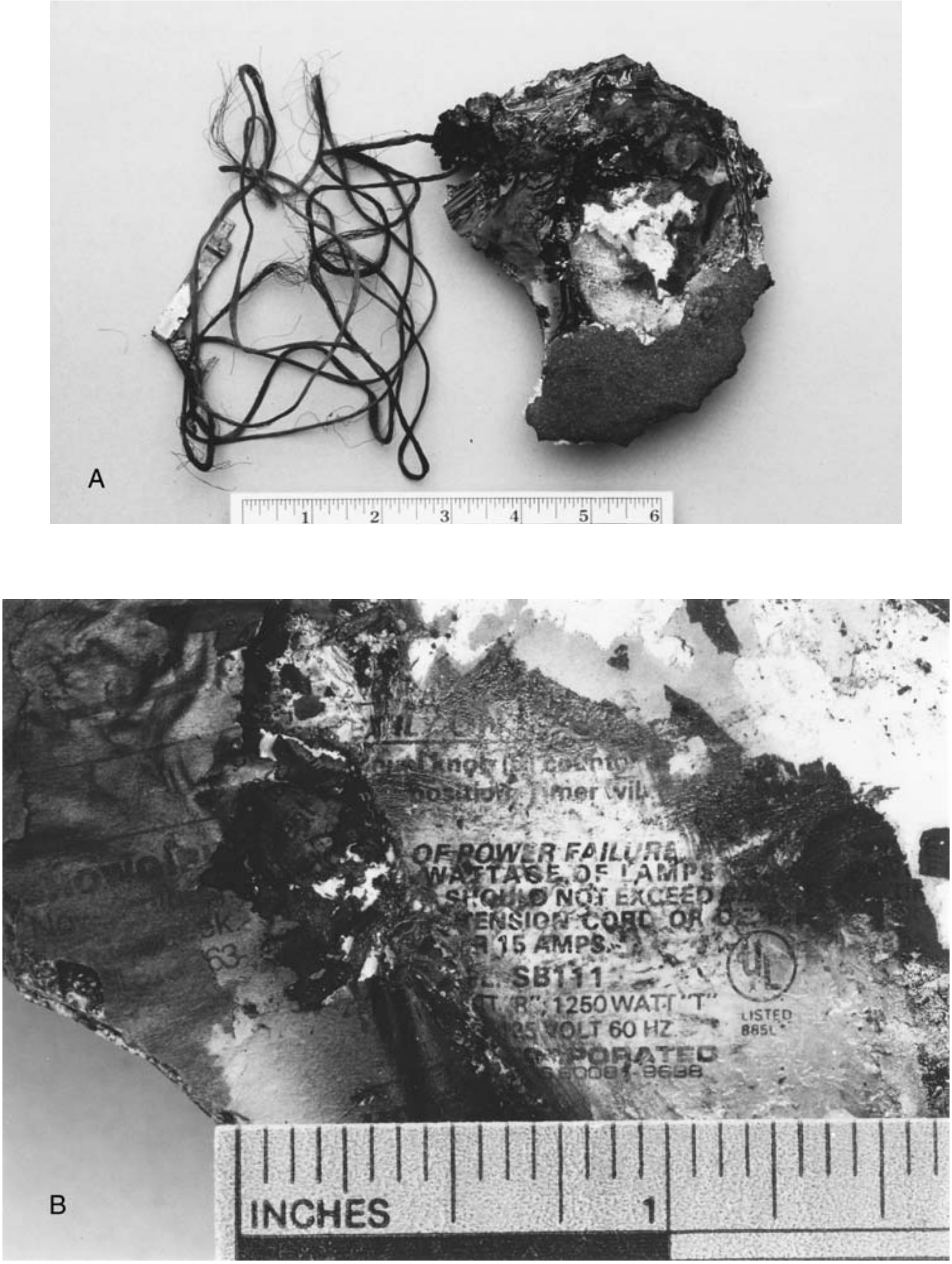

Figure 11.16 (A color version of this figure follows page 256.) A melted electrical timer device (A) and a close-up (B) showing a portion of a label believed to have been used in an arson case. The example of the intact timer (C) was used in the reconstruction of the device. *(Los Angeles County Sheriff's Department.)*

furthest from the seat where fragments from the explosion are located will define the outer perimeter of the scene. A buffer area equal to approximately half the distance from the seat to the furthest point should be added. This represents the total area that should be secured and searched (Figure 11.15).

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Figure 11.16 (continued)

The bomb scene should be recorded. This may be accomplished in the standard way by means of photography and sketches. If the capabilities exist, the scene may be videotaped. If needed, aerial photographs should be taken. Photographing, measuring, and sketching the crime scene may be done while the scene is searched.

Collecting physical evidence at the scene consists of the search for and recovery of items that may lead to information about the nature and type of explosive and the identity of the suspect. A search for the fusing mechanism of the bomb should be made. Items such as timing mechanisms, batteries, pieces of wire, safety fuses, blasting cap debris, and the like may yield information about the way in which the bomb was set to detonate. The scene should be searched for evidence to determine the type of explosive used. The seat of the explosion should be carefully examined for unexploded material and packaging material that may indicate the type of explosive used. If a portion of the container that held the device is found, laboratory tests may indicate the type of explosive. Similarly, the extent of damage to the container, for example, a pipe bomb, can indicate whether the explosive was a low-order or high explosive. In general, large fragments of a pipe bomb indicate a low explosive such as black powder, while small fragments indicate a high explosive.

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Figure 11.17 On opening a small parcel delivered to his home, a man was killed when a 2-m length of detonating cord wrapped tightly inside a food can exploded. A detailed examination of the bomb scene located a large amount of debris in which metal pieces from the rim of the food can were found. The investigator observed marks about 1 mm in diameter and opined that they were made by the feeder wheel of a can opener. After a detailed study to prove that tool marks from can opener feeder wheels left marks on can rims that were individual, the investigator was able to prove that the suspect's can opener made the marks found on the can at the scene of the explosion. *(South Australian Police, Adelaide, South Australia.)*

The package that contained the explosive device may contain evidence to lead the investigator to a suspect. Fingerprints, names, addresses, and postmarks may be important information in the investigation. The investigator should not forget to search for other evidence besides the bomb debris. Items such as fingerprints, tire tracks, tool marks, and the like are valuable and must not be overlooked.

If a suspect is apprehended shortly after the explosion, the clothing should be collected and submitted to the laboratory for examination for trace evidence and explosive debris. The suspect's hands should be swabbed with cotton applicators moistened with acetone to test them for certain explosives. If the suspect's vehicle is located, it too should be

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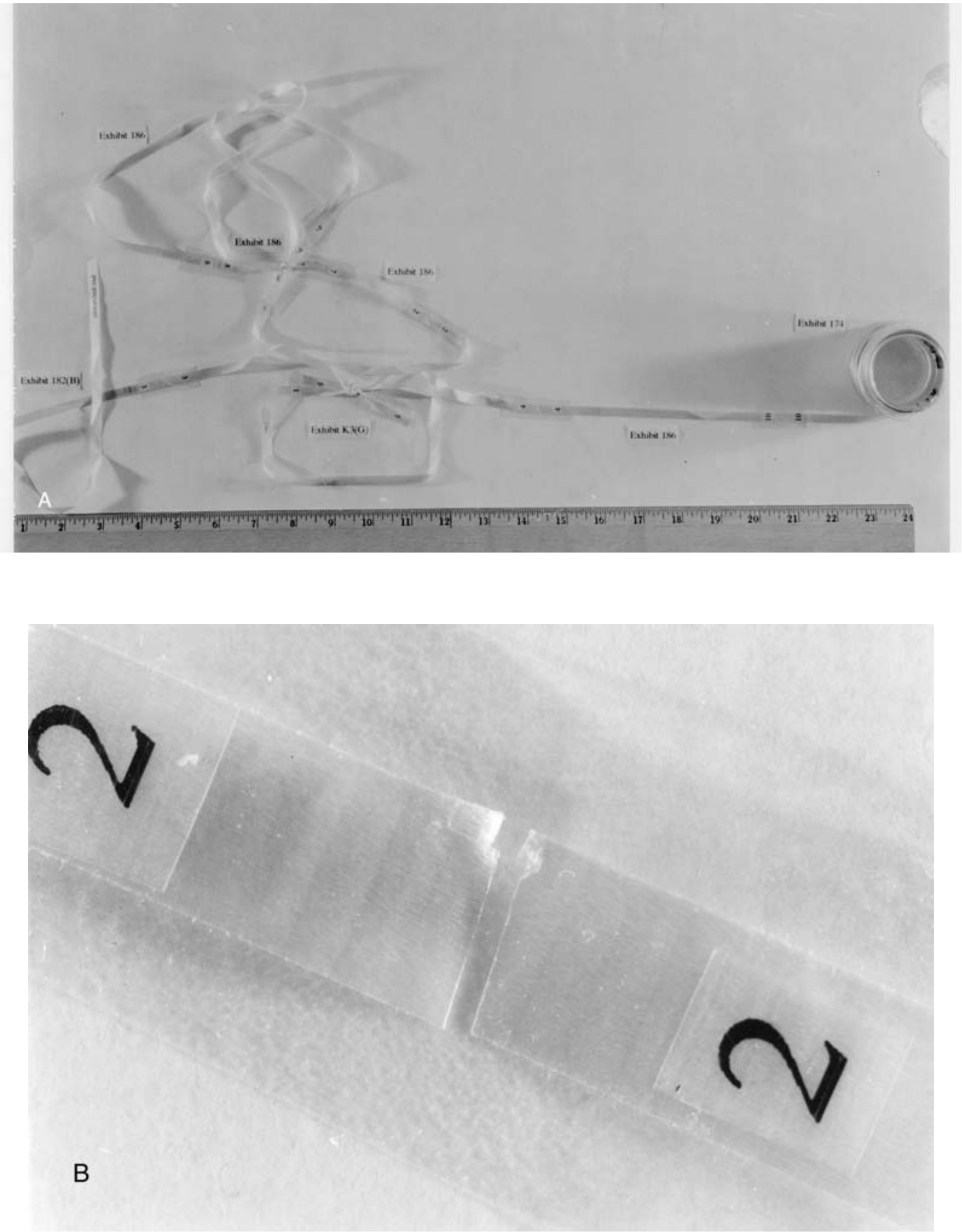

Figure 11.18 Ribbon used to wrap the package (A) and matching ends (B). (*U.S. Postal Service.*)

carefully searched for tools, trace evidence, explosive residue, and materials that may have been used in the crime (Figure 11.18).

All evidence should be photographed where it was found, measured, and located on a crime scene sketch prior to being moved. The investigator should remember also to search high areas such as trees, roofs, ledges of buildings, and other places that may contain pieces of the exploded device.

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Because of the large number of persons involved with the bomb scene search and the amount of evidence collected, it is helpful to keep an evidence log to detail each item of evidence collected, including the date, time, and name of the person collecting the material. The use of a log facilitates establishing a chain of evidence and makes inventory of all the evidence somewhat easier.

The crime laboratory plays an important role in bomb scene investigation. Often the nature of the explosive used and information about the type of mechanism used to detonate it cannot be determined in the field. The laboratory will carefully and systematically examine all the items of evidence and attempt to answer some of the questions required by the investigator to assist in the solution of the case.

Bomb and arson scene investigations require much time and patience, and crime scene investigating officer's extreme attention to detail. The officer's willingness to carefully and painstakingly go through large amounts of debris and rubble in an attempt to locate pertinent physical evidence may result in a successful conclusion to the case.

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Investigating Sexual Assault and Domestic Abuse Crimes

13

Rape

Few crimes rely so heavily upon physical evidence as does the crime of rape. In few other cases is the testimony of the victim viewed with as much mistrust by juries, courts, and sometimes even prosecutors and police. It is for this very reason that physical evidence is so important to the investigation and prosecution of this crime. Rape investigation is different from many other major crimes. Unlike homicide, robbery, or assault, the first officer at the crime scene is required to play a much greater part in the collection and preservation of physical evidence. In a murder investigation, the first officer's responsibilities are to secure the crime scene until the investigators arrive. This is not the case in a rape investigation. The first officer is required to make certain that fragile physical evidence that may be lost during the medical examination or by the victim are collected and preserved.

Preliminary Interview

The first officer must be knowledgeable about the types of evidence generally found at the rape crime scene. The officer must also be a skilled interviewer in order to elicit from the victim the painful details of the assault, and from these details determine what evidence may be available.

The first officers at a rape scene may find that training in crisis counseling will help them assist the victim in dealing with her trauma. Outmoded attitudes that women provoke rape or deserve it because they placed themselves in the situation have no place in modern police theory. The victim should be treated nonjudgmentally and with sensitivity. Observations about the victim noted in the crime report will be important at a later time. The psychological state of the victim may be significant. The officer should realize, however, that people in serious emotional crises might not immediately exhibit states of anguish and grief that might be expected. The victim might appear perfectly calm and in control of herself when interviewed by the police. This behavior is not uncommon.

The officer should not assume that the victim is untruthful because she is not exhibiting extreme emotion. Statements in police reports, such as "the victim appeared unusually

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calm, considering her complaint of rape," do nothing but confuse the investigation and raise doubt at the trial. The investigator should be aware that many rape victims do not volunteer particularly sensitive details of the assault. Questions about oral and anal intercourse should be asked. The officer should ascertain whether the victim is sexually experienced and hence able to testify whether penetration and/or ejaculation took place.

After a rape, the victim may feel psychologically dirty. She may have a compulsion to wash, bathe, douche, throw away her clothing, and clean up the scene of the rape. During the interview, the officer should determine which, if any, of these actions occurred. If any did, an attempt to collect evidence should still be made. A tissue or washcloth used by the victim to clean herself might still have semen present. Underwear and clothing worn at the time of the crime, even if discarded or cleaned, should be collected for examination. The crime scene should be processed as outlined elsewhere in this book but several other aspects require attention. What was the M.O. of the suspect? Did he practice any unusual acts, such as urination or defecation? Did he do or say anything unusual? Is there any physical evidence to substantiate these acts? Did he bite the victim? Was the victim or suspect scratched or bruised? All of these details, together with any physical evidence, will greatly assist the investigation of the case.

Medical Examination

Following the preliminary interview, the victim should be taken to a hospital emergency room or clinic for a thorough examination. Because much of the evidence associated with rape is of a fragile nature, time is of the essence. The victim should be taken to the emergency room as rapidly as possible. A change of clothes should be obtained so that the clothing worn during the rape may be collected. Many hospital emergency rooms have protocols established to deal with rape victims in which they are ranked in medical priority immediately after life-threatening cases. Hospitals are responsible for the victim's medical and psychological well-being, as well as the collection of physical evidence.

Once the victim has been transported to the hospital, the officer should briefly go over the case with the attending physician or nurse. Pertinent information gleaned from the interview should be given to the doctor because it may facilitate the examination for physical evidence. The doctor first takes a medical history from the victim and again goes over the details of the assault. Doctors should be encouraged to take detailed notes and later couple the notes with medical findings during the examination phase. Details such as the date of the last menstruation, time of last consensual intercourse, presence of bruises not related to the assault, presence of bruises from the assault, and other related factors are pertinent information.

Following the medical history, the doctor should conduct a thorough physical examination. Some hospitals only examine the genital area and miss a great deal of useful evidence. The location of any cuts, bruises, lacerations, or contusions should be noted in the medical report. A helpful practice is the use of an anatomical diagram. The location of cuts, bruises, and the like can be charted on this diagram. If the victim is wearing clothes from the assault, they should be collected and packaged in a paper bag. A chain of custody for any evidence collected during the medical examination should be started. Many hospitals, police departments, and commercial hospital or law enforcement supply firms have sexual assault evidence kits (Figure 13.1). These kits greatly facilitate the collection and

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Figure 13.1 Example of a sexual assault evidence collection kit. *(Los Angeles County Sheriff's Department.)*

preservation of rape evidence. They also direct the physician to look for certain evidence commonly found in rape cases.

Following the medical history and a cursory examination of the victim, photographs of bruises or wounds may be taken. If the hospital does not have this capability, the police officer may take the victim to the police station for this purpose. In some instances, the officer may wish to wait a day or so until the bruises become black and blue and better show the location and extent of the assault. The victim should next be carefully examined for trace evidence adhering to her body. The location of any debris, grass, soil, vegetation, dried semen, dried blood, loose hair, fibers, and so on should be noted and collected. The presence of dried seminal fluid, dried blood, and dried saliva (from bite marks) is especially useful because such evidence may be typed by forensic DNA testing. Using a slightly moistened cotton-tipped applicator easily preserves this evidence.

Following examination of the extremities and torso, the genitalia are examined. Some facilities use a UV lamp (or Wood's lamp) to examine for the presence of seminal fluid. Semen fluoresces under ultraviolet light. Next, pubic hair combings are taken in an attempt to find foreign hairs and fibers or other debris. The hairs, any debris, and comb are all submitted for examination. As with all other evidence, these items should be appropriately documented in the medical report and labeled to maintain a chain of custody. A vaginal specimen is collected with two cotton-tipped applicators and a portion is smeared on two microscope slides (Figure 13.2). The slides should be air-dried and *not* stained. The slides should be placed in a slide protector, *not* in alcohol. Finally a vaginal aspirate is taken. Three to five cubic centimeters of sterile saline are used.

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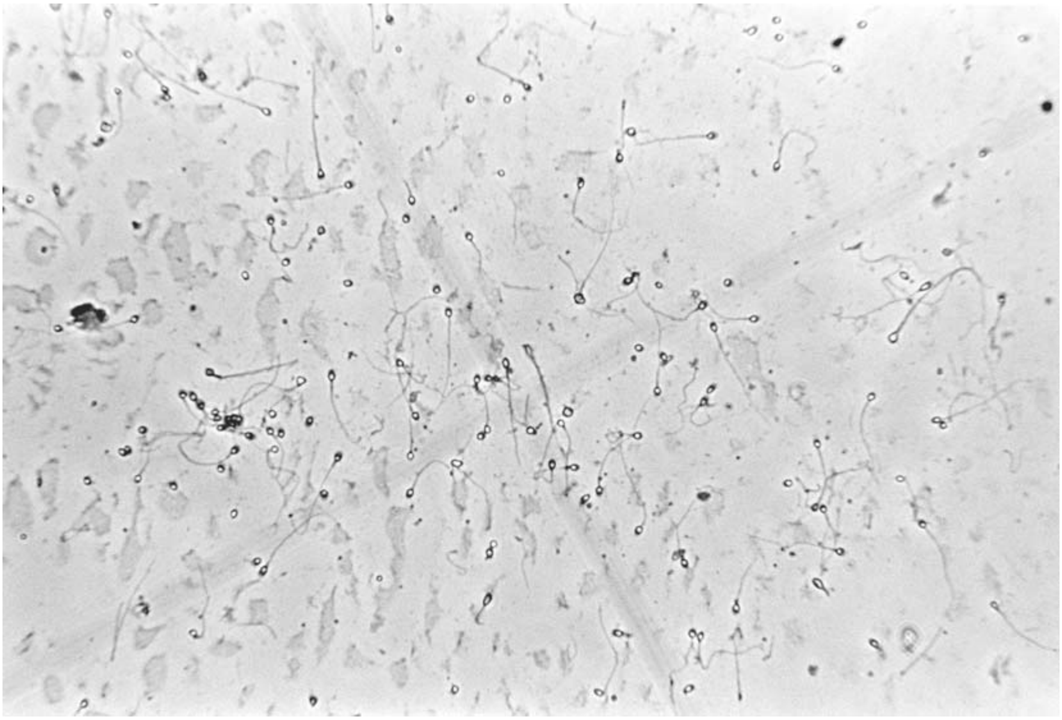

Figure 13.2 Microscopic examination of a vaginal smear may disclose the presence of spermatozoa, which is helpful in establishing an element of the crime of rape, vaginal penetration. *(Los Angeles County Sheriff's Department.)*

Collection of Physical Evidence

Other evidence should be collected if indicated. If anal or oral intercourse occurred, appropriate rectal and oral swabs should be collected. Fingernails may be examined and if sufficient debris is present, nail scrapings can be collected. Toxicology samples should be collected if the victim appears to be under the influence of some substance. Physical evidence collected in rape cases is used for three major purposes:

1. **To establish that penetration occurred.** The presence of seminal fluid and spermatozoa in the vaginal pool is suggestive of vaginal penetration. The presence or absence of this evidence can be explained in any number of ways. The absence of seminal fluid in a case in which it was expected could be caused by the following reasons:
   - The time period between the rape and medical examination was too long.
   - The suspect wore a condom; the suspect penetrated but did not ejaculate in the vagina.
   - The doctor did not take an adequate sample.
   - Seminal fluid and spermatozoa may be present from a consensual intercourse and not from an alleged rape. In this instance, seminal fluid typing is indicated.
2. **To establish that nonconsensual intercourse occurred.** Physical evidence may prove that the victim did not consent to the intercourse. Evidence such as torn or

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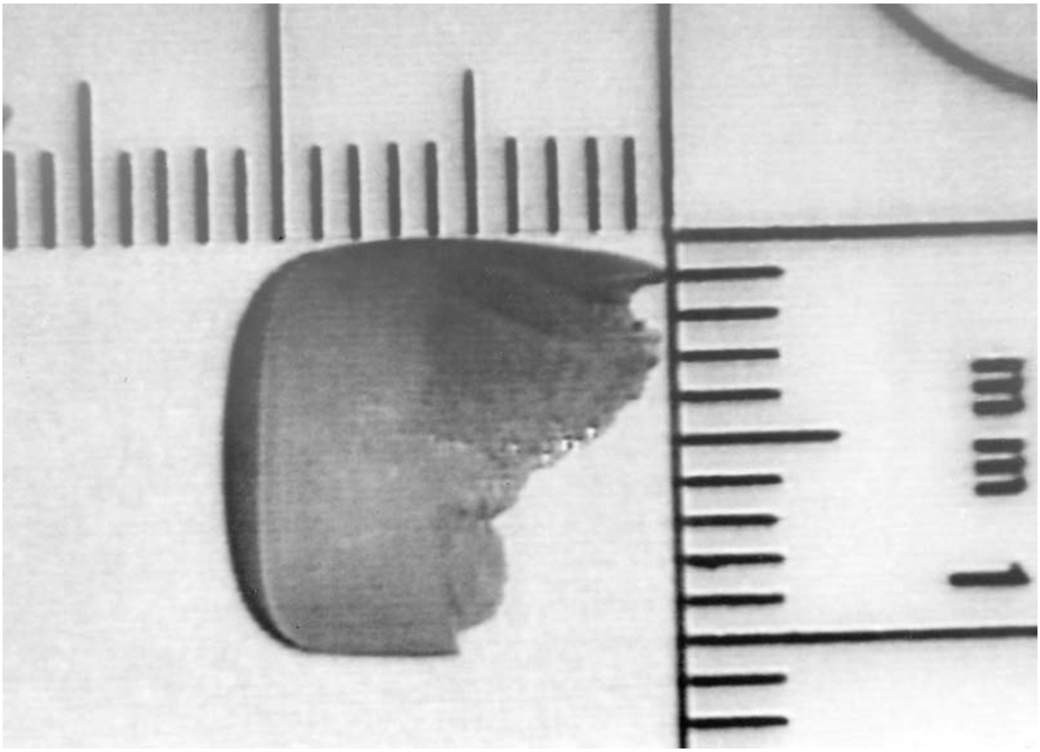

Figure 13.3 Broken fingernails are sometimes found at sexual assault scenes. Such evidence may serve to place the victim at the crime scene. There is also a good chance that the assailant's blood may be present, which makes DNA typing a reasonable possibility. *(Los Angeles County Sheriff's Department.)*

soiled clothing, bruises, pulled-out hair, cuts, and other indications assist in proving that a struggle occurred during the time of the intercourse, hence rape (Figure 13.3).

3. **To establish identity of the perpetrator.** The suspect's identity may be established by usual means: eyewitness testimony, fingerprints, hair, fibers, or bloodstains left behind at the scene. Additionally, it may be possible to determine the assailant's DNA type through seminal fluid typing or typing of cellular material at the hair root (especially prevalent with freshly pulled hairs). The suspect may have left an article of clothing at the crime scene or unknowingly picked up some trace material such as fibers from a rug or clothing. A cigarette butt, beer can, or piece of paper may yield fingerprint evidence. All are possible from a carefully and thoroughly conducted crime scene investigation (Figures 13.4 and 13.5).

Rape evidence should be refrigerated and submitted to the crime laboratory quickly. Much of the biological evidence deteriorates rapidly, particularly evidence that is to be typed. Crime laboratory tests involving comparative analysis such as hair examination and blood and semen typing require known specimens. Semen and saliva specimens require known blood and saliva samples from the parties involved in the investigation. Rape investigation presents unusual challenges to the investigator. Issues such as myths about rape, psychological trauma of the victim and, in some cases, the investigator's feelings of discomfort in dealing with the victim must be addressed when investigating this crime of violence.

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Figure 13.4 As with broken fingernails, pulled-out hairs resulting from a struggle are also useful evidence. If the hair root is present as shown in this case, PCR DNA typing should be considered if identity is an issue in the case. *(Los Angeles County Sheriff's Department.)*

Date-Rape Drugs

If during the course of an investigation, the victim makes a statement such as, "I was at a party, and this guy gave me a drink. Next thing I know, it's morning and I'm in someone's bed. I've no idea what happened in between," consider the possibility of use of drugs like Rohypnol or gamma-hydroxybutyrate (GHB).

Rohypnol, known by various street names: Roachies, La Roche, Rope, Rib, Roche, Rophies, Roofies, and Ruffies, is the brand name of a sleeping pill marketed by Roche Pharmaceuticals in Mexico, South America, Europe and Asia, but not in the U.S. Rohypnol belongs to the family of medications called benzodiazepines that includes Valium (diazepam) and Librium (chlorodiazepoxide). During the past few years, abuse of Rohypnol has increased; this was initially reported in Florida and Texas, but is now spreading to other regions. Much of the Rohypnol abused in the U.S. is obtained by prescription in Mexico and transported across the border. Rohypnol is a fast-acting sedative that can render a victim unconscious within 20 to 30 minutes. Combined with alcohol, it can lead to coma and possibly death. It also produces complete or partial amnesia.

GHB (or gamma-hydroxybutyrate) has a number of street names such as "grievous bodily harm," "liquid ecstasy," and "easy lay," plus a host of other names depending on the region of the country. GHB is a depressant affecting the central nervous system and its effects are rapidly felt. Like "Ruffies," it can cause amnesia, unconsciousness, coma, and sometimes (when combined with alcohol) death. GHB generally comes in pure powder

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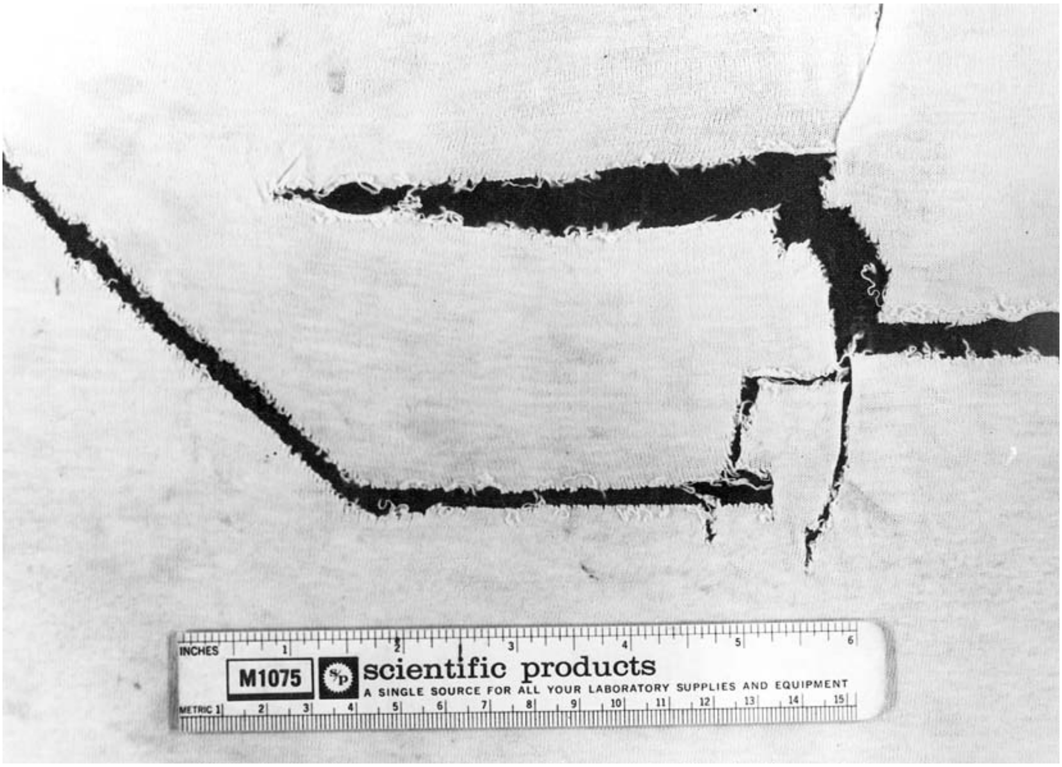

Figure 13.5 In this rape case, the victim's hands were cut while reaching for a knife. The suspect tore off the bottom of his undershirt and gave it to the victim to bandage her hands. A physical match of the torn pieces conclusively shows that the shirt was once whole. *(Santa Ana Police Department, Santa Ana, California.)*

form or mixed with water. Body builders sometimes use it. In 1989, the FDA banned the sale of GHB and classified it as a Schedule I drug. A number of states have passed legislation outlawing the possession of GHB by making it a Schedule I drug under state law.

GHB is a liquid that can render a victim unconscious with as little as a teaspoonful mixed into a drink. The onset of symptoms comes within approximately 5 to 20 minutes. The victim has a feeling of extreme intoxication and impaired judgment. GHB does not produce the extreme muscle paralysis and memory loss associated with Rohypnol, but can cause unconsciousness and strong memory impairment.

The collection of a blood and urine specimen upon admission to the ER for analysis is key to the effective investigation of drug-induced sexual assault cases. The cooperation of the emergency room in the collection of specimens greatly helps law enforcement in such cases.

Victims who experience being drugged or are suspicious that they may have been drugged should refrain from voiding their bladders. If voiding is necessary, any clean container is suitable for a urine collection. GHB is eliminated rapidly from the blood (less than 6 hours), but it may be detected in urine. Samples collected from 12 to 24 hours post-dose will yield negative results.

Finally, investigators should collect any portion of the drink, if it is available, for laboratory examination. Also, if any powdery or crystalline material or pills are found, they too should be sent to the crime laboratory.

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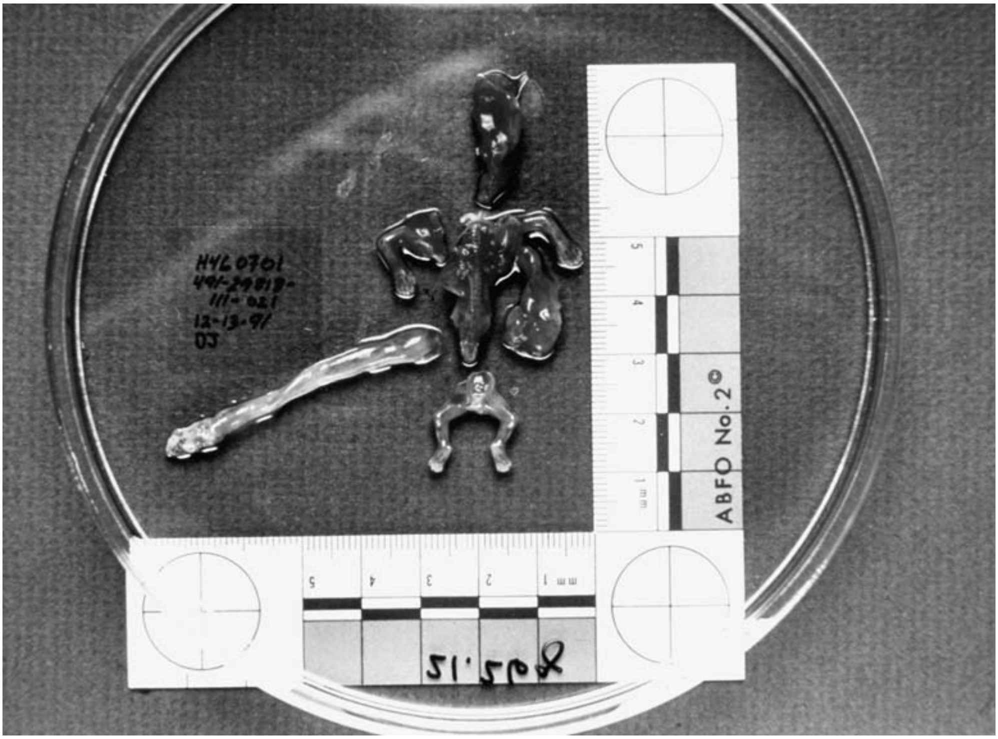

Figure 13.6 In cases in which pregnancy results from a case of rape or incest and the pregnancy is terminated, the fetus is a source of DNA from the father and mother. Such cases have successfully used forensic DNA typing to prove a subject was indeed the father of the fetus. *(Los Angeles County Sheriff's Department.)*

Other Sexual and Abusive Assaults

Sexual Child Molestation and Incest

Child molestation and incest investigations have two related problem areas: difficulty in interviewing the victim and possible problems regarding the child's competency to testify in court. These difficulties, coupled with the family's reluctance to pursue or cooperate in the matter, make these cases a challenge. The key person in a sexual assault case involving children is the physician. The physician's ability to examine the victim and document findings of sexual assault is of major importance in this type of case. Because of the usual inability of the victim to testify, the physical evidence and medical testimony are particularly important. Child psychologists are also playing an increasing role in child abuse and child molestation cases. They help investigators by pointing out specific child behavior patterns generally associated with this type of crime. However, investigators should be aware that a child psychologist might inadvertently cause a young victim to color his or her story so as to tell the psychologist what he or she "wants to hear."

Physical evidence is often minimal in child molestation cases. The child's parents are often unaware of the crime. Telltale signs of child molestation such as nightmares, bed-wetting, urinary tract infections, and strange stories eventually lead parents or authorities to a suspicion of the cause. If molestation is suspected, the police are brought into the

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investigation. If clothing is available from a recent assault and has not been laundered, it should be collected. Beyond this, the police will need to rely heavily on medical findings. Child abuse cases also rely upon the findings of the pediatrician. Here, unexplained bruises, x-rays showing broken bones, and so forth will be important in the investigation. In addition to physical abuse, instances of malnutrition and poor hygienic conditions may occur. These types of cases are almost always emotionally charged and are difficult to prosecute and take to trial. To be sure, these crimes certainly do occur; however, investigators must be especially careful in these cases. Innocent people's names can be tarnished irrevocably if a careful investigation is not made.

Homosexual Assault

Anal intercourse or sodomy is not limited to female victims. Male homosexual sexual assaults occur with some frequency in jail and prison environments as well as elsewhere. Of particular importance in these cases is the physician's examination of the rectum as well as swab evidence taken for the examination of semen. Medical examination conclusively indicates if anal penetration has occurred and whether the person was accustomed to anal intercourse. Beyond the medical examination and search for semen, other evidence is sometimes uncovered in such cases. Feces may be found on clothing or other articles. A lubricant such as petroleum jelly may be used and should be looked for.

Elder Abuse[1]

Elder abuse represents an emerging area of concern. Broadly defined, there are three basic categories of elder abuse:

1. Domestic elder abuse
2. Institutional elder abuse
3. Self-neglect or self-abuse

Domestic elder abuse generally refers to any of several forms of maltreatment of an older person by someone who has a special relationship with the victim (e.g., a spouse, sibling, child, friend, or caregiver in the older person's home or in the home of a caregiver).

Institutional abuse, on the other hand, generally refers to any of these forms of abuse that occur in residential facilities for older persons (e.g., nursing homes, foster homes, group homes, board and care facilities). Perpetrators of institutional abuse usually are persons who have a legal or contractual obligation to provide elder victims with care and protection (e.g., paid caregivers, staff, professionals).

Elder Physical Abuse

Physical abuse is defined as the use of physical force that may result in bodily injury, physical pain, or impairment. It may include but is not limited to such acts of violence as striking (with or without an object), hitting, beating, pushing, shoving, shaking, slapping, kicking, pinching, and burning. In addition, the inappropriate use of drugs and physical restraints, force-feeding, and physical punishment of any kind also are examples of physical abuse.

[1] This material is adapted from the National Center on Elder Abuse web page, located at http://www.elderabusecenter.org/basic/index.html. The NCEA is an excellent resource for elder abuse investigations.

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Signs and symptoms of physical abuse include:

- Bruises, black eyes, welts, lacerations, and rope marks
- Bone fractures, broken bones, and skull fractures
- Open wounds, cuts, and punctures, untreated injuries in various stages of healing
- Sprains, dislocations, and internal injuries/bleeding
- Broken eyeglasses or frames, physical signs of being subjected to punishment, and signs of being restrained
- Laboratory findings of medication overdose or underutilization of prescribed drugs
- An elder's report of being hit, slapped, kicked, or mistreated
- An elder's sudden change in behavior
- The caregiver's refusal to allow visitors to see an elder alone

Elder Sexual Abuse

Elder sexual abuse is defined as nonconsensual sexual contact of any kind with an elderly person. Sexual contact with any person incapable of giving consent is also considered sexual abuse. It includes but is not limited to unwanted touching and all types of sexual assault or battery, such as rape, sodomy, coerced nudity, and sexually explicit photographing.

Signs and symptoms of sexual abuse include:

- Bruises around the breasts or genital area
- Unexplained venereal disease or genital infections
- Unexplained vaginal or anal bleeding
- Torn, stained, or bloody underclothing
- An elder's report of being sexually assaulted or raped

Elder Emotional or Psychological Abuse

Emotional or psychological abuse is defined as the infliction of anguish, pain, or distress through verbal or nonverbal acts. This type of abuse includes but is not limited to verbal assaults, insults, threats, intimidation, humiliation, and harassment. In addition, treating an older person like an infant; isolating an elderly person from his or her family, friends, or regular activities; giving an older person the "silent treatment;" and enforced social isolation are examples of emotional or psychological abuse.

Signs and symptoms of emotional/psychological abuse include:

- Being emotionally upset or agitated
- Being extremely withdrawn and noncommunicative
- Unusual behavior usually attributed to dementia (e.g., sucking, biting, rocking)
- An elder's report of being verbally or emotionally mistreated

Elder Neglect

Neglect is defined as the refusal or failure to fulfill any part of a person's obligations or duties to an elder. Neglect may also include failure of a person who has fiduciary responsibilities to provide care for an elder (e.g., pay for necessary home care service) or the failure on the part of an in-home service provider to provide necessary care. Neglect typically means the refusal or failure to provide an elderly person with such life necessities

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as food, water, clothing, shelter, personal hygiene, medicine, comfort, personal safety, and other essentials included in an implied or agreed-upon responsibility to an elder.

Signs and symptoms of neglect include:

- Dehydration, malnutrition, untreated bedsores, and poor personal hygiene
- Unattended or untreated health problems
- Hazardous or unsafe living conditions or arrangements (e.g., improper wiring, no heat, or no running water)
- Unsanitary and unclean living conditions (e.g., dirt, fleas, lice on person, soiled bedding, fecal/urine smell, inadequate clothing)
- An elder's report of being mistreated

Elder Abandonment

Abandonment is defined as the desertion of an elderly person by an individual who has assumed responsibility for providing care for an elder or by a person with physical custody of an elder.

Signs and symptoms of abandonment include:

- The desertion of an elder at a hospital, nursing facility, or other similar institution
- The desertion of an elder at a shopping center or other public location
- An elder's report of being abandoned

Financial or Material Exploitation of Elders

Financial or material exploitation is defined as the illegal or improper use of an elder's funds, property, or assets. Examples include:

- Cashing an elderly person's checks without authorization or permission.
- Forging an older person's signature
- Misusing or stealing an older person's money or possessions; coercing or deceiving an older person into signing any document (e.g., contracts or will)
- The improper use of conservatorship, guardianship, or power of attorney

Signs and symptoms of financial or material exploitation include:

- Sudden changes in bank account or banking practices, including unexplained withdrawals of large sums of money by a person accompanying the elder
- The inclusion of additional names on an elder's bank signature card
- Unauthorized withdrawal of the elder's funds using the elder's ATM card
- Abrupt changes in a will or other financial documents
- Unexplained disappearance of funds or valuable possessions
- Substandard care being provided despite the availability of adequate financial resources
- Discovery of an elder's forged signature being used for financial transactions and for the titles of his or her possessions
- Sudden appearance of previously uninvolved relatives claiming their rights to an elder's affairs and possessions

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- Sudden unexplained transfer of assets to a family member or someone outside the family
- The provision of unnecessary services
- An elder's report of financial exploitation

Self-Neglect

Self-neglect is characterized as behavior of an elderly person that threatens his health or safety. Such behavior generally manifests in an older person as a refusal or failure to provide himself with adequate food, water, clothing, shelter, personal hygiene, medication (when indicated), and safety precautions. The definition of self-neglect excludes a situation in which a mentally competent older person, who understands the consequences of his decisions, makes a conscious and voluntary decision to engage in acts that threaten his health or safety as a matter of personal choice.

Signs and symptoms of self-neglect include:

- Dehydration, malnutrition, untreated or improperly attended medical conditions, and poor personal hygiene
- Hazardous or unsafe living conditions or arrangements (e.g., improper wiring, no indoor plumbing, no heat, no running water)
- Unsanitary or unclean living quarters (e.g., animal/insect infestation, no functioning toilet, fecal/urine smell)
- Inappropriate or inadequate clothing, lack of necessary medical aids (e.g., eyeglasses, hearing aids, dentures)
- Grossly inadequate housing or homelessness

Who Are the Perpetrators of Elder Abuse?

Elder abuse, like other types of domestic violence, is extremely complex. Generally, a combination of psychological, social, and economic factors, along with the mental and physical conditions of the victim and the perpetrator, contributes to the occurrence of elder maltreatment. Although the factors listed below cannot explain all types of elder maltreatment because it is likely that different types (as well as each single incident) involve different casual factors, they are some of the causes that researchers say are important.

Caregiver Stress

Caring for frail older people is a very difficult and stress-provoking task. This is particularly true when older people are mentally or physically impaired, when the caregiver is badly prepared for the task, or when the needed resources are lacking. Under these circumstances, the increased stress and frustration of a caregiver may lead to abuse or willful neglect.

Impairment of Dependent Elder

Some researchers have found that elders in poor health are more likely to be abused than those in good health. They have also found that abuse tends to occur when the stress level of the caregiver is heightened as a result of a worsening of the elder's impairment.

Cycle of Violence

Some families are more prone to violence than others because violence is a learned behavior transmitted from one generation to another. In these families, abusive behavior is the

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normal response to tension or conflict because they have not learned any other ways to respond.

Personal Problems of Abusers

Researchers have found that abusers of the elderly (typically adult children) tend to have more personal problems than do nonabusers. Adult children who abuse their parents frequently suffer from such problems as mental and emotional disorders, alcoholism, drug addiction, and financial difficulty. Because of these problems, these adult children are often dependent on the elders for their support. Abuse in these cases may be an inappropriate response by the children to the sense of their own inadequacies.

Who Are the Abusers?

More than two thirds of elder abuse perpetrators are family members of the victims, typically serving in a care-giving role.

In most states, the APS (adult protective services) agency, typically located within a human service agency, is the principal public agency responsible for investigation of reported cases of elder abuse and for providing victims and their families with treatment and protective services. In most jurisdictions, the county departments of social services maintain an APS unit that serves the needs of local communities.

However, many other public and private agencies and organizations are actively involved in efforts to protect vulnerable elder persons from abuse, neglect, and exploitation. Some of these agencies include: the state unit on aging; the law enforcement agency (e.g., police department, district attorney's office, court system, sheriff's department); the medical examiner or coroner's office; hospitals and medical clinics; state long-term care ombudsman's office; health agency; area agency on aging; mental health agency; and facility licensing/certification agency.

Adult Protective Services

In most jurisdictions, APS, the Area Agency on Aging, or the county Department of Social Services is designated as the agency to receive and investigate allegations of elder abuse and neglect. If the investigators find abuse or neglect, they make arrangements for services to help protect the victim.

Medicaid Fraud Control Units (MFCU)

Every State Attorney General's Office is required by federal law to have an MFCU to investigate and prosecute Medicaid provider fraud and patient abuse or neglect in health care programs that participate in Medicaid, including home health care services.

Conclusion

Crimes referred to as "sexual assault" are improperly named. In reality, they have little to do with sex except that the genitals may be involved. They are in fact crimes of violence frequently involving suspects exhibiting "non-normal" psychological behavior. The investigator who understands the psychological as well as the physical evidence aspects of these crimes will likely be more effective in the investigation.

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14 Burglary Investigation

Burglary is one of the most commonly encountered crimes investigated by police. Because the nature of the crime is so varied it is difficult to set down specific guidelines for its investigation. Many of the techniques and procedures outlined in earlier chapters of the text are pertinent to the burglary investigation. This chapter discusses some of the aspects of crime scene investigation that deal more specifically with the crime of burglary.

The first officer to arrive at the burglary scene must be concerned with the suspect's location. In cases in which the burglary is in progress and the officer was called because of the presence of a prowler, silent alarm, or ringing burglar alarm, the first consideration must be to apprehend the suspect. Once the suspect has been located or a determination has been made that the suspect is not at the scene, the location must be secured. Witnesses should next be located and separated for interviewing at a later time.

The crime scene search should commence. The officer conducting the crime scene investigation of a burglary should understand that most experienced burglars attempt to leave only a minimum amount of evidence at the location. The officer should also remember that it is impossible for the suspect not to change the crime scene in some small way by leaving traces behind or by picking up small items of evidence when leaving the scene. The officer must therefore collect evidence left behind by the suspect, e.g., fingerprints, shoe prints, tool marks, etc., and evidence from the suspect that may have been removed from the scene, e.g., glass fragments, paint chips, wooden splinters, etc. The investigator should also be aware of the *modus operandi*, or M.O., of the burglar. Frequently, a suspect may be responsible for a large number of burglaries in an area and similarities in the cases may enable the investigator to concentrate on one rather than a number of suspects. Thus, in some instances it may be useful to examine tool marks left at different crime scenes in order to determine whether the same tool was used.

Points of Entry

The point of entry is an important location of physical evidence in burglary investigations. The experienced burglar attempts to gain entry by the easiest and safest available entrance.

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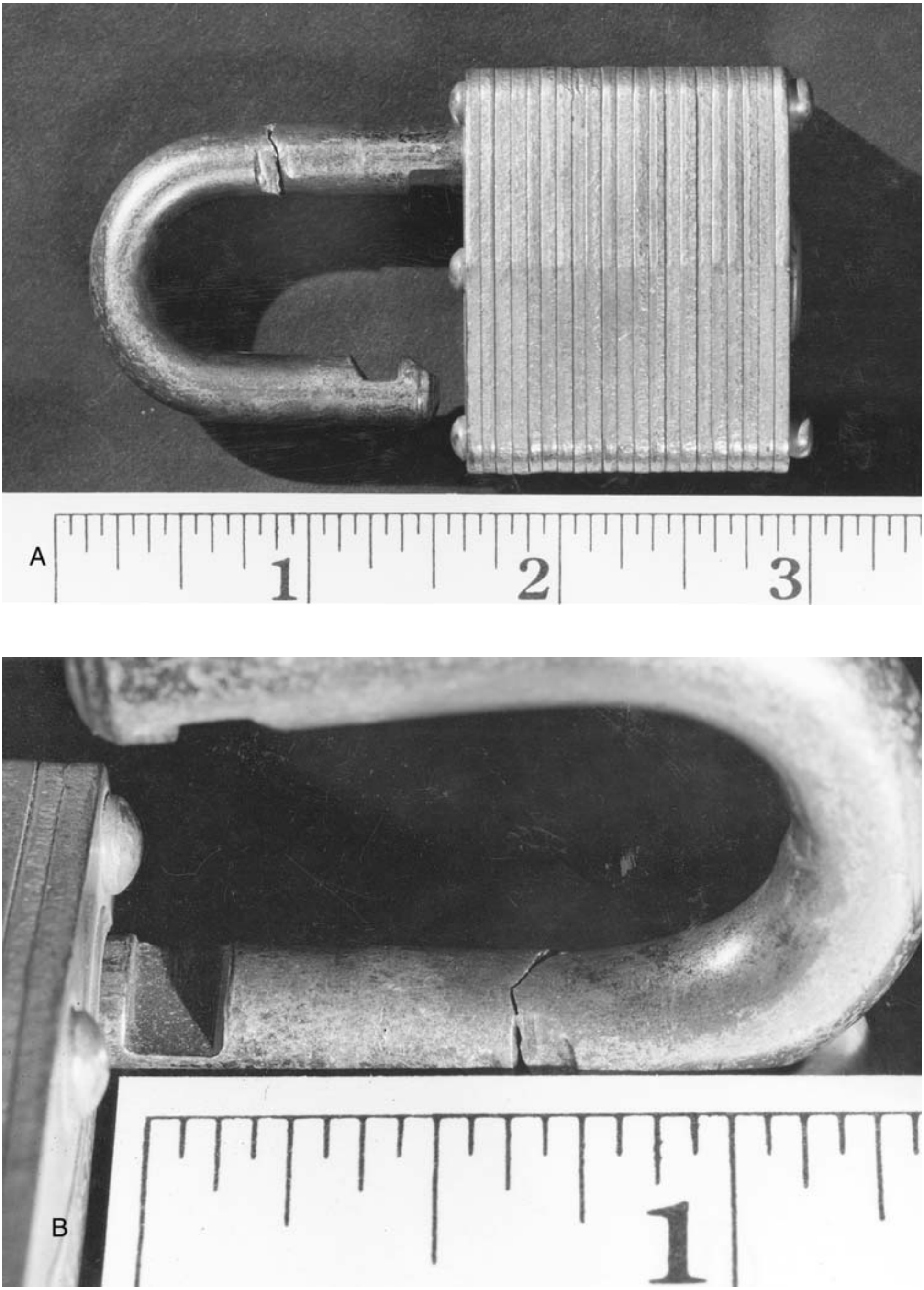

Figure 14.1 Evidence in a burglary case: (A) a cut lock hasp and (B) close-up of the hasp shown pieced together. *(Los Angeles County Sheriff's Department.)*

Entry through Windows

Window entry is usually accomplished by breaking a hole through a pane and removing the broken glass to reach the latch. In order to minimize the noise from falling glass, the burglar may press a rag against the window; sometimes adhesive tape may be used. In

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some cases, the burglar may remove the entire windowpane by removing the putty holding the glass in place. It has even happened that the burglar has replaced the glass intact and put in new putty. Where a screen covers a window, a careful examination of the edges for any cuts may show fibers from the sleeve where the suspect's arm was inserted to open or break the window. Glass is one type of evidence often found on the suspect when a window was broken to gain entrance. When the window is broken it is almost unavoidable that some pieces of the flying glass will adhere to the suspect's clothing. The investigator should collect specimens of the broken window for possible comparison with glass found on the burglar's clothes and also search for any fingerprints present on the windowpane, as well as prints present in the window putty (Figure 14.2).

Similarly, fingerprints should be looked for in the dust that may be present on the window or ledge. Entry may also be gained by forcing in a tool to push back a window latch. In such cases, tool marks should be looked for and samples of wood and paint should be taken for comparison if a tool is later found. A pry bar, screwdriver, or other tool is also sometimes used in forcing a window. In these cases, tool marks and specimens of building debris should be collected. Sometimes the burglar may try to force several different windows in order to enter the building. The investigator should therefore examine all windows to determine if any jimmy marks are present and collect appropriate tool mark evidence. Paint chips frequently are dislodged during the course of breaking in and the investigator should always collect samples for later comparison. Later, examination of the suspect's clothing and tools may uncover paint that matches paint recovered at the crime scene (Figure 14.3).

Entry through Doors

A burglar usually opens a door by using a pry bar to attack the door and jamb around the lock until the bolt can be pushed back or is actually freed from the striker plate. A door jamb is sometimes so weak that it may be spread apart far enough to free the bolt. This can be done by mere pressure from the body or by inserting a jack horizontally across the doorframe. The lock might also be made accessible through a hole that is drilled, sawed, or broken in a door panel. Far too many doors are fitted with glass that is simply broken so that the lock may be reached. Other weak points are mail slots, the frame of which may be removed, and transoms that may have been left open. A common method of entry is to push back spring-loaded bolts by means of a knife. The knife is inserted between the door and the jamb and the bolt is gradually worked back. The bolt is kept from springing back by outward pressure on the door. This method is easily detected by the series of scratches that run lengthwise along the bolt. Burglary by this method is prevented by safety catches and deadbolt locks. Snap-lock bolts can also be opened by inserting a knife, spatula, or credit card pressed against the beveled face of the bolt and pushing it back. The instrument can be inserted between the door and the jamb or behind the molding on the jamb (Figures 14.4 and 14.5).

This method of entry is generally difficult to detect because a piece of plastic can be used without leaving any marks. It is, however, possible that pieces of plastic broke off and may be found in or near the lock. On locks on which the beveled face of the bolt faces inward, the bolt may be pushed back by a suitable tool or a piece of wire that forces the bolt back by a pulling movement. This is usually discovered by scratch marks on the face of the bolt. Special attention should be given to the opening for the bolt in the striker plate

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Figure 14.2 A window is often a point of entry in a case of breaking and entering or burglary. This screen shows prying marks in the lower left corner. *(Los Angeles County Sheriff's Department.)*

for the possibility that it may contain wadded paper or other material. It has happened that a burglar surreptitiously stuffed something in the opening in the door jamb during an earlier visit to the premises. The effect of the wadding is to prevent the bolt from locking so that the burglar may later return and push the bolt back. If there is reason to suspect that the lock has been picked, the lock should be disassembled with great care. The investigator should avoid making new scratch marks inside the lock. If a pick has been used, it may have left marks in the coating of dust and oil usually found inside locks. Broken knife points, metal fragments from lock picks, and the like may also be found inside the lock. Cases have been recorded in which mechanics who installed the lock made certain alterations in order to facilitate a later burglary.

Entry can also be gained by cutting the hinge pins off by means of a bolt cutter. More commonly, however, the pins are simply knocked out with hammer and chisel or screwdriver. With the pins out, the door can be lifted off the hinges. The door may then be replaced and the pins reinserted. This method of entry is readily revealed by the damage to the hinges and the chips of paint or metal on the floor below the hinges. Cylinder (pin-tumbler) locks may be picked by special picks, but usually the whole door is forced or the cylinder is removed. The cylinder may be pulled out by means of a special puller shaped from a pair of large nippers. To avoid detection of the removal, the lock cylinder is sometimes replaced or a similar cylinder put in its place. Sometimes the retaining screw is removed surreptitiously during an earlier visit to the premises, which facilitates removing the cylinder. Still another means of gaining access through a door is by means of a wrench

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Figure 14.3 Burglary tools such as these may be a source of many types of physical evidence such as paint, glass, other building materials, tool marks, etc. *(Los Angeles County Sheriff's Department.)*

placed on the doorknob. The twisting motion exerted on the doorknob is sufficient to defeat the locking mechanism of inexpensive locking devices. Examination of the doorknob shows characteristic markings caused by the tool. The doorknob should be removed and submitted to the laboratory for comparison with tool marks made by the wrench and also for comparison of any metal shavings found in the teeth of the tool. In instances in which a padlock was used on a hinged hasp to lock a door, the padlock and cut shackle should be collected and sent to the laboratory. If a pair of bolt cutters or similar cutting device is found, test cuts can be made and compared with tool marks left on the lock shackle (Figure 14.6).

Entry through Basement Windows and Skylights

These windows are forced in the same manner as ordinary windows, but the investigator should pay special attention to the possibility that the burglar's clothes may have become torn and cloth fragments or fibers left behind. The officer should also take samples of the dust and dirt usually found in such places.

Entry through Roofs

The presence of convenient utility poles, ladders, and other aids, plus the concealment of the edge parapet, makes entry through flat roofs a favorite M.O. Many otherwise well-protected stores have "tissue-paper" roofs. Building material may contaminate the clothing of any burglar using this technique. A careful search will also show signs of ropes for entry and exit. Most stores are equipped with roof ventilators and exhaust fans. Entry through

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Figure 14.4 Exterior doors are another favorite point of entry. *(Los Angeles County Sheriff's Department.)*

the ventilating system may result in tool marks, fingerprints, and dust contamination of clothing.

Entry through Walls

Walls are broken by tools or by explosives. A brick wall is easily broken by a hammer and chisel or a sledgehammer. Burglars can be expected to become covered with dust during such an operation; samples of mortar and brick should be collected for comparisons. In blasting, a hole is usually chiseled between two bricks and the charge is inserted. Several small charges are normally used in order to avoid severe detonations and the possibility of the whole wall collapsing. Small hydraulic jacks may be used to force holes into a wall. In this operation, a narrow passageway is usually chosen where the base force can be distributed over a wide area by padding. After the initial hole is made, repeated thrusts are used to enlarge the hole sufficiently to gain an entry. When an empty or infrequently occupied store is adjacent to the target, plaster walls may be cut to a thin supporting layer and the entire section removed at once. Entry into vaults is usually accomplished through the walls, which are easier to force than the door. The walls are often constructed of reinforced concrete that can be broken by repeated blasting or by hammer and chisel and oxyacetylene torch.

Entry through Floors

This method of entry is often preferred in the case of warehouses or other buildings that have a crawl space underneath. The burglar usually drills or saws a hole in the floorboards

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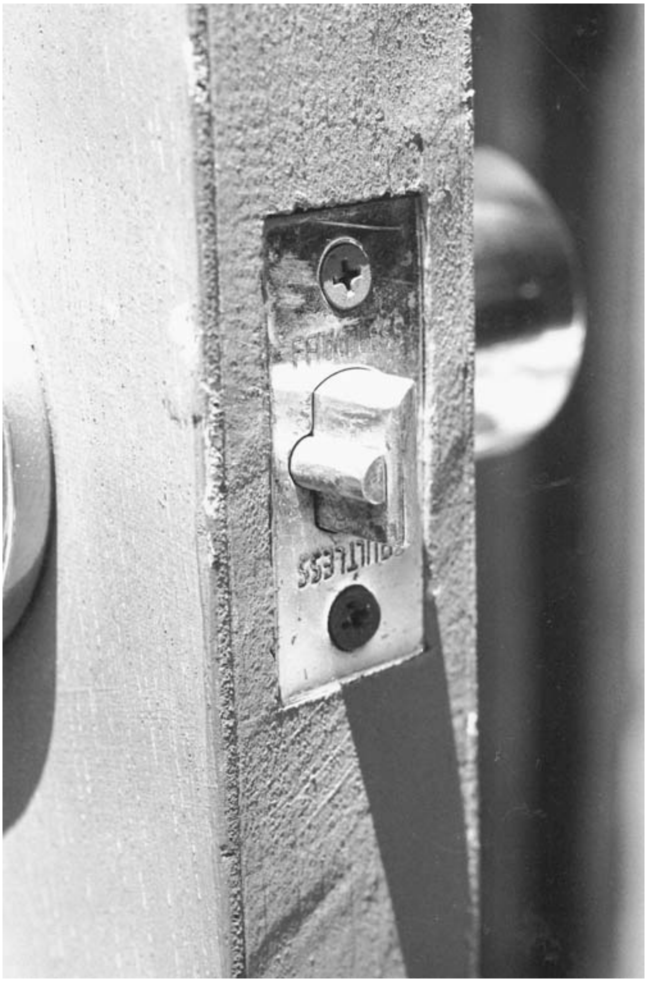

Figure 14.5 Scratches are easily visible on this spring-loaded bolt. *(Los Angeles County Sheriff's Department.)*

large enough to crawl through. Entry through walls and floors is also made when the criminal suspects or knows that the premises are protected by burglar alarms on doors and windows.

Simulated Burglaries

Simulated burglaries are often attempts at insurance fraud. To create a successful imitation of a burglary that will deceive the police, the simulator must strive to carry it out as naturally as possible. Otherwise there will be gaps in the sequence of events. When windows are entered, the officer should therefore always check whether the windowpanes were in fact broken from the outside, whether footprints are outside the window, whether broken glass has been trampled in these prints, whether the burglar really could have reached the window, whether there are traces of actual entry (sand, dirt, etc.), whether objects inside the window are so placed that the window could be opened to permit entry, and so on. If the outside of the window glass is very dirty, there should be marks from the object used

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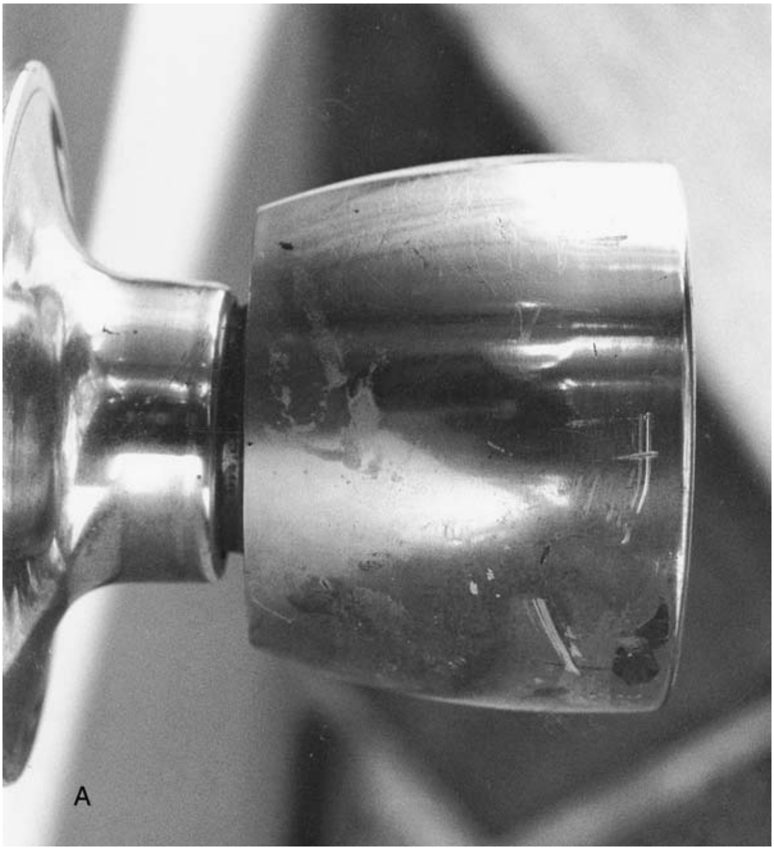

Figure 14.6 An exterior doorknob showing tool marks (A) and a pair of adjustable grips on a doorknob (B). Investigators should never attempt to match a tool to an object in this fashion. *(Los Angeles County Sheriff's Department.)*

to break it. If the glass is relatively clean, the side on which the force was applied might be revealed by dusting with fingerprint powder. In cases of forced doors, the damage should be examined to see whether it is only on the outside portions. Marks of prying should be present on the door as well as on the door jamb. If the tool marks are located so high up that the burglar must have stood on a box or a ladder, the support should be examined. Whenever a burglary is suspected of being simulated, all tools belonging to the victim should be compared with the tool marks present and, if necessary, recovered for further examination. Holes in floors, walls, and ceilings should be examined to determine the side from which the attack was started. The holes should also be examined to determine any evidence of a person having crawled through. The officer should further make an estimate of how long the burglar spent on the premises. The officer should follow the burglar's actions in searching for valuables — were doors first opened and drawers emptied or did the burglar go directly to the location of the valuables?

Detailed Examination of the Scene

Generally, the detailed examination of the crime scene proper should begin only after the surrounding areas have been searched. Failure to search the surrounding areas initially

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Figure 14.6 (continued)

may result in the inadvertent destruction of evidence by sightseers as well as officers at the location. Approaches leading to and away from the scene should be examined for footprints, tire impressions, drag marks (such as those caused by a heavy object, e.g., a safe), and abandoned items such as tools, clothing, opened cash boxes, and so on. Obstacles leading to the building such as fences and gates should be examined for traces of blood, fabric and fibers, and tool marks. The number of suspects involved should be estimated from footprints when possible. Areas where a suspect had to crawl or climb should be examined for traces of clothing. Samples of building material and soil should be collected for comparative purposes (Figure 14.7). The location from which the burglar "staked out" the location or where a "lookout" was standing should be examined for footprints, cigarette butts, cigarette package wrappers, matches, and other such items. The point of entry should be examined for broken tools, tool marks, broken window glass, fibers, hair, blood, fingerprints, footprints, paint chips, wood, and other building materials (Figure 14.8). Known samples of materials should be collected. Photographs, measurements, and sketches should, as always, be made before any items are moved or collected. The examination of the interior of the burglarized premises must sometimes be carried out while taking into account the wishes of the owner. Business activities cannot be completely stopped. The investigator may allow the owner or manager to specify which area of the premises is available for searching first.

The investigator should carry out the inside crime scene investigation in the normal detailed and systematic way. Attention should be given to evidence such as fingerprints, footprints, broken tools, tool marks, blood, and any other evidence that will aid in the solution of the case. As the examination of various areas of the location is completed, the proprietor should be notified. If evidence is found that requires time-consuming recovery,

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Figure 14.7 A footprint showing little definition. Investigators should consider the possibility of comparing soil at the scene with any noted on a suspect's shoes. *(Los Angeles County Sheriff's Department.)*

the owner and other personnel should be asked to stay out of the area until the examination is complete. A complete inventory of all items missing should be obtained from the owner, as well as a complete description of the items, including brand names, labels, markings, serial numbers, size, shape, color, and value. This facilitates identification of the stolen property in the event the items are recovered.

An apprehended suspect should be thoroughly searched. Cuts and scratches should be noted. The clothing should be collected for examination for tears and building material that can place the suspect in contact with the crime scene. The suspect's vehicle should be searched for stolen property, burglary tools, and any other items of physical evidence. The investigator should remember that in some instances a search warrant might be necessary before the vehicle may be completely searched.

The investigator should attempt to form a picture of the whole crime scene in order to estimate whether or not the burglar was familiar with the premises. If the burglar removed valuables from a rather unlikely location without disturbing the rest of the scene or if keys that were hidden were used, the officer might infer that the suspect was familiar with the location. The investigator should try to make a determination about the type of person being sought. Was the burglary the work of a professional burglar? Was the crime simply a case of vandalism involving juveniles? Was anything unusual left at the scene such

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Figure 14.8 Many items of evidence may need to be considered in a burglary: tool marks on the bolt and doorknob, paint, wood, building material, glass, etc. Investigators need to be aware of these when searching for physical evidence in such cases. *(Los Angeles County Sheriff's Department.)*

as feces, which might point to a suspect with a history of sex-related crimes? Answers to these questions, information obtained from interviews, and physical evidence examination will prove useful in the overall investigation.

Safe Burglaries

Safes may be classified into two basic types: fire-resistant and burglar-resistant. Although providing a minimum resistance to attack by a professional burglar, fire-resistant safes are designed to withstand, resist, and retard the penetration of heat and to protect documents from destruction by fire. Such safes are constructed of metal and insulation consisting of a variety of materials such as vermiculite, cement, diatomaceous earth, sawdust, and the like. Burglar-resistant safes are specifically designed to resist the efforts of safe burglars and are constructed of steel that is resistant to forced entry by tools or

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torch. Burglar-resistant safes are not burglarproof, but are designed to resist attack for a certain period of time.

Safes can be opened by a number of methods such as manipulation, punching, peeling, prying, ripping, chopping, drilling, burning, or by means of explosives. *Manipulation* is essentially a lost art that involves opening a safe by means of listening to and feeling the combination lock mechanism. Most safes today have manipulation-proof locks; the investigator should therefore assume that the suspect had knowledge of the combination if a safe in which the lock has been opened is found. The *punching* method involves knocking off the dial and punching the dial spindle into the safe. Newer safes have punch-proof spindles and relocking devices that automatically relock the safe when an attempt at a "punch job" is made. Peeling involves *prying* or *peeling* the faceplate from the safe door in such a way as to expose the locking mechanism. This is sometimes accomplished by first pounding the door with a sledgehammer until the door buckles and then inserting a pry bar. Entry by *ripping or chopping* is achieved by tearing a hole through a part of the safe other than the door such as the top, side, or bottom. *Drilling* is usually effective but it is a time-consuming method and therefore only rarely used in safe burglaries. It is commonly done by perforating the doorplate around the keyhole by a series of holes close together. A large portion of the lock mechanism is thereby bared so that the bolts can be manipulated. The front plate of some safes can also be peeled back if some of the screws or rivets in the edge are first removed. The paint covering the rivets is first scraped off so that the rivets are bared. The rivets are then drilled deeply enough for the plate to be separated. After a few rivets have been removed, the front plate is then forced up sufficiently to insert a chisel used to break the remaining rivets without drilling.

On some safes the locking bolts can be reached by drilling through the side of the safe, directly against the face of the bolt. The bolt can then be driven back with a punch. The exact location of the bolts can be determined by the marks in the door frame that occur in daily use when the safe door is shut while the bolts are protruding. In cases of drilling, the burglar can be expected to have used some kind of lubricating oil for the bit. Samples of such oil and samples of metal shavings should be collected because the burglar's body or clothing may contain these materials. Simpler types of safes with combination locks may be opened by means of a thick, square steel plate provided with an opening at the center to be slipped over the dial knob. The corners of the plate are equipped with threaded bolts, the points of which touch the safe door. By tightening the bolts with a wrench, the knob and spindle are torn out. It also happens that safes are opened by a special bridge device screwed to the safe with bolts. The portion of the bridge over the door frame contains a threaded hole. A strong bolt is fitted into this hole and tightened far enough to force the door open.

Another method employs a circular cutter. Such devices are made in several different forms. Some are affixed to one or more holes that have been drilled into the safe, while others are strapped to the safe by long bolts and nuts or steel cable. Common to all types, however, is one or more hardened steel cutters held against the safe under tension and turned by means of a handle. The result is a round hole in the safe wall. These devices are normally not used on the safe door because the locking bars would interfere, but rather on the side or back of the safe. Cutting by oxyacetylene torch is a very effective method against which only specially designed steel chests are completely resistant. A considerable disadvantage of this method lies in the fact that the apparatus required is heavy and difficult to transport. For this reason, the burning method is usually used only where complete

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welding equipment is available on the premises. Some burglars have used compact equipment that is large enough to do the job but light enough to be carried easily.

Burning is another method used by safe burglars using the so-called "burning bar." The bar, a metal pipe, is packed with a mixture of powdered aluminum and iron oxide. The mixture is known as *thermite* and when ignited gives off a very intense heat that can be directed to the safe. Burning is usually started around the dial hole. A sufficiently large hole is cut in the front plate of the door so that the lock mechanism is accessible. The operator may cut this hole in the form of a tongue that is folded back. Where the cutting is done on the sides or back of the safe, the inside plate must also be cut through. This method often ignites the contents of the safe, whereupon the burglar may use a soda pop bottle as a fire extinguisher. Sometimes the burglar cuts off the safe door hinges, which reveals an ignorance of the construction of the safe. The manner of opening the safe by burning reveals the skill of the burglar. When the investigator is unable to estimate this skill, a specialist should be consulted. Samples to be collected at the scene are molten particles of metal (beads), slag, molten safe insulation, and the like. Such particles may be found on the clothing of a suspect.

The investigator should also keep in mind the possibility of minor burns in the burglar's clothes from flying particles. When the contents of the safe caught fire, the burglar may have been able to recover paper currency, some of which may be charred. Safe burglaries are often carried out by transporting the safe to an isolated location where it is opened by tools or explosives. In such cases the burglars are usually less careful in their movements at the place of opening. Valuable footprints or tire tracks may be found at such places. The investigation should be carried out as soon as possible because inclement weather conditions may destroy the most valuable evidence.

Safe Burglary Case

A safe was hauled out during a burglary and transported in a car to a wooded area where it was opened with explosives. During the examination of the outdoor scene, a door handle from an automobile was recovered. The car of a suspect who was later arrested for the burglary was found to have a broken handle. The handle from the scene matched the remains of the handle on the car. It had apparently been broken off while the safe was taken out of the car. The suspect confessed.

Safe Burglaries Using Explosives

It is sometimes very difficult to gather physical evidence that will convict a safe burglar specializing in explosives. As a rule, the burglar is skilled at this method and takes pride in sweeping the crime scene clean of all traces that may be used as incriminating evidence. When examining such burglary scenes, the investigator should therefore proceed very thoroughly and take advantage of the mistakes sometimes made even by this type of burglar.

Experience has shown that these burglars usually make mistakes when disturbed or when fleeing the premises. The burglar may then leave behind or drop objects that have

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potential value as evidence. One weakness of these specialists is that they usually stick to one method in all their burglaries. The investigator thereby gets an opportunity to tie certain burglaries to a given criminal or to others whom they have trained. This fact may be valuable even when the burglars are not known. Explosives operators usually do not pick locks or make their way into the premises by other light-fingered methods. Their work is carried out with a great deal of noise and this is also characteristic of their method of entry. They generally use great force on doors and windows and may even use a charge on a door that could much more easily have been opened the usual way. On the other hand, they are very careful to protect themselves from surprise. They very rarely work alone and may have several helpers whose only duty is to act as lookouts.

Regarding the placing of the safe for the "blowing," three methods are normally found: it is left in place, it is pulled out from the wall, or it is laid on the floor. The first method is the most common. The second is used by burglars who do not want to have the safe blown against the wall and create vibrations in the building that may be more noticeable than the detonation. It has happened that a safe was thrown so violently against the wall that it broke the wall and started cracks that ran into an apartment above. The third method is seldom used; its advantage is that it facilitates the placing of the charge.

In examining safes that have been moved or laid down the investigator should be very careful in searching for latent finger and palm prints. Although explosives specialists will be sure to use gloves or other covering, it is still possible that they may leave identifiable fragments of palm prints on a safe that they have moved. The glove may slip during the heavy work, exposing a small piece of the palm, enough to produce a valuable print. In developing prints deposited under such conditions, great care must be exercised because they easily become smeared or even completely filled in because of the great pressure.

The charge is usually placed in the dial spindle hole after the dial is knocked off; it may be dynamite in powder or paste or other explosives. The hazard and the refined technique associated with the use of nitroglycerine usually limit its use to only the elite of the safe burglars. Round door safes have discouraged the use of explosives, however. Wrappers from explosives should be searched for and recovered, even though latent fingerprints are usually not found on waxed wrappers. In a favorable case the wrapper may still be valuable as evidence. In general, the adhesive material used to affix the detonator that is found on the scene, such as clay, putty, plasticine, or soap, is brought in by the burglar. These substances must be soft and well kneaded in order to serve the purpose. Because the burglar may have kneaded these materials without wearing gloves before going to the scene, plastic fingerprints may be present. Such prints should be searched for not only on the surface but also on inside layers of the kneaded material.

Plastic prints may also be found on strips of tape, but these are usually difficult to detect. The amount of safety fuse — when it is used — may vary in length. Explosives specialists usually cut these lengths before going to the scene and have widely varying ideas of the proper length — a fact that may have some value. Those using the longer fuses usually prefer to light the fuse and then retire to a safe place from which they can observe the effect of the explosion and whether it was noticed. Safe burglars vary as to whether they use a dam or sound-absorbing blanket to contain the explosion. Those who do use a dam probably do so to muffle the detonation and to keep windows from bursting. Because the charge is mostly inside the door, the effect of the explosion is not enhanced by the use of a dam. When the burglar intends to demolish the door completely, the dam does have some effect but it is usually an effect that he wants to avoid. The burglar runs the risk that

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the inside door plate is blown into the safe with such force that new charges must be placed to dislodge it. Many explosives specialists make a habit of not using a dam at all. Instead, they open windows in the room in which the safe is located so that the shock wave will dissipate without breaking windows or attracting unwanted attention. Some burglars soak the dam with water, partly to make it denser and heavier and partly to prevent the possibility of fire. The materials used in dams are brought to or collected at the scene. The damage to the material gives an indication of how many separate charges were used.

Material that has been brought to the scene may sometimes give good leads for the investigation and the search for the criminal. The ideal explosion occurs when the charge is so well balanced that the locking bolts are pulled back and the door flies open. In such cases, the external damage to the safe may be limited to a slight bulge in the front plate around the dial hole. It does happen, however, that the locking bolts remain more or less closed, so new charges must be set off. In order to avoid this snag, some burglars put weight on the door handle in the direction in which the handle opens. A heavy cord is commonly tied to the handle and a heavy object is attached to the other end. Another method is to tie a heavy metal bar to the handle to act as a lever. At the detonation, the handle is turned by the weight of the heavy object so that the locking bolts are turned back. Locked drawers and compartments inside the safe are either forced open or blown. The investigator should keep in mind the possibility of finding parts of broken tools as well as tool marks at these places.

Fragments of tools should be searched for with a magnet because they are very difficult to find in the powdered insulation that usually pours from the broken safe. The search for fingerprints at scenes of safe blowing is usually complicated by the layer of finely divided safe insulation that settles on everything in the room. This dust should be removed, preferably by careful blowing, before developing with powder. To brush off the dust is wrong because the dust usually consists of gritty particles that will destroy the fingerprints. Visible prints that have been deposited by a dusty finger must be treated very carefully. Whenever an unexploded charge is found in the safe it should be neutralized with great care. An apprehended suspect's clothes should be thoroughly searched for the presence of safe insulation or paint. Anyone who has been present in a room where a safe has been blown can hardly avoid getting dust and safe insulation on his or her clothing. The dust may also adhere to the burglar's skin or in the hair, ears, and nostrils and under the fingernails. Such dust may be found on any part of the clothing, but particularly in the pant cuffs and on the shoes, mainly in the seams and lace holes and on the soles.

In addition, paint chips are usually loosened in the explosion and the burglars run the risk of picking them up on their clothing when examining the safe after the detonation. In searching the scene, the investigator should therefore collect samples of the safe insulation and paint on the outside and inside of the safe for use in possible comparisons and also evaluate the possibility of wall paint loosened by the explosion falling on the burglar. The investigator should note the manufacturer of the safe so that the company may later be contacted for information on the composition of insulation and paint. If safe insulation or paint is not found on the suspect's clothes, the investigator should remember that the he might have done everything possible to eliminate such traces. The suspect's hands and clothing should also be examined for the presence of trace explosives. If the hands were not immediately washed, traces may be under the fingernails. In the clothing, such traces should primarily be searched for in the pockets — even the gloves may contain traces. If

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the burglar carried safety fuses in pockets, there may be characteristic stains on the pocket lining.

When a safe is blown, the burglar may be injured by the sharp metal edges. It may also happen that the nose starts bleeding from the shock of the detonation. This is more common when electric detonators are used because the burglar is forced to stay rather close to the safe. If blood is found at the scene, it should be recovered for later examination. The burglar may possibly be so severely injured that immediate aid must be sought. Burglary is such a common crime that frequently a less than thorough investigation is conducted; however, a careful and detailed examination of the crime scene may result in developing evidence useful in an ultimate solution of the case.

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Motor Vehicle Investigation 15

Case

D. Cotton, a 23-year-old male residing on Vincent Street, Hendon (a suburb of Adelaide), South Australia, died as a result of a motor vehicle accident. He was the sole occupant of a Gemini sedan, which had overshot an intersection in the Adelaide Hills suburb and slammed into a solid stone wall. The Gemini was, in fact, registered to a Mr. Caffrey living on the same street as Cotton. When the police went to question Mr. Caffrey at his home about why Cotton had been driving his car, they found that he had been murdered. Caffrey's body had numerous knife wounds. The crime scene investigation suggested a sole assailant. The Gemini was examined and a bloodstained knife was found in a plastic bag in the rear compartment. The tip of the knife had been snapped off. Postmortem examination showed stab wounds to the head. The possibility of the knife having left a piece of blade in the skull was confirmed when an x-ray revealed a small metal fragment lodged in the skull behind the left ear. A physical match between the piece of metal and the knife confirmed it as the murder weapon. Combined with the blood evidence (on the knife and a glove worn by Cotton), and the location of bloodied shoe sole impressions at the scene, which were similar in size and pattern to Cotton's shoes, the State Coroner was satisfied that Cotton had been responsible for the death of Caffrey and had stolen his car[1] (Figures 15.1 through 15.4).

The widespread use of motor vehicles in today's society has resulted in automobiles being associated with many different types of police investigations. Motor vehicles may be the instrument of crimes such as hit-and-run cases or traffic fatalities. A vehicle may also be a crime scene, for example, in cases in which a crime was committed in an automobile or in cases of auto theft. This chapter deals with evidence commonly associated with crimes in which a motor vehicle is involved.

[1] This case was submitted by Sergeant Ted Van Dijk, Police Forensic Science Section, South Australian Police Department, Adelaide, South Australia.

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Figure 15.1 An apparent automobile accident led to an unexpected turn of events. *(South Australia Police Department, Adelaide, South Australia.)*

Figure 15.2 (A) The police found the owner of the vehicle murdered. (B) The autopsy revealed numerous stabbings. *(South Australia Police Department, Adelaide, South Australia.)*

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Figure 15.2 (continued)

Vehicle Theft

A vehicle may be stolen by juveniles for "joyriding," in connection with another crime as a means of fleeing, or for the purpose of stripping the vehicle of parts to be sold for profit. Unfortunately, vehicle theft is a crime of rather high frequency and some police agencies do not have the personnel resources with which to conduct thorough investigations. This often results in a search for physical evidence that consists of only dusting the vehicle for latent fingerprints. Stolen vehicles may be located in a variety of circumstances. Often uniformed officers while on patrol observe them. The officer may make use of a "hot sheet" listing licenses of stolen vehicles, use a description from a police bulletin or broadcast, or notice some furtive movement on the part of the driver that results in a routine traffic stop and subsequent check for a stolen vehicle (Figure 15.5).

Once the vehicle has been identified as stolen, the examination for physical evidence begins. A short preliminary investigation will determine whether a full search for physical evidence is needed. In instances in which the driver of the stolen vehicle turns out to be the thief, the need for identity determination by means of physical evidence is removed. It is still necessary to check out the vehicle carefully and inventory the property. It is a good idea to look for evidence of other crimes. In some instances an automobile was

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Figure 15.3 (A) Burglary tools, including a bloody knife, were found in the vehicle. (B) The tip of the knife was broken off. *(South Australia Police Department, Adelaide, South Australia.)*

recovered and at the officer's request towed to an impound yard. Some days later, much to the officer's chagrin, a dead body was discovered in the trunk.

It is possible the theft may be only one of other, more serious crimes; with this in mind, the first officer to locate the stolen vehicle should take appropriate precautions. As with other crime scenes, the most fragile evidence should be collected first. This usually means fingerprints. It is recommended that the vehicle be moved to a special location such as a tow yard or police garage for the purpose of taking prints and looking for other physical evidence. Furthermore, before any extensive search is undertaken, the need for a search warrant should be considered.

When the vehicle is moved, care should be taken not to destroy fingerprints or other evidence. If possible, the vehicle should be towed to the impound yard. Driving it might accidentally destroy certain evidence. Personnel at the tow yard should be reminded not to touch the vehicle until it has been processed for evidence. If the vehicle is wet from dew it should first be allowed to dry. In cold weather, the vehicle should be placed indoors and allowed to warm up to room temperature prior to taking fingerprints. The examination

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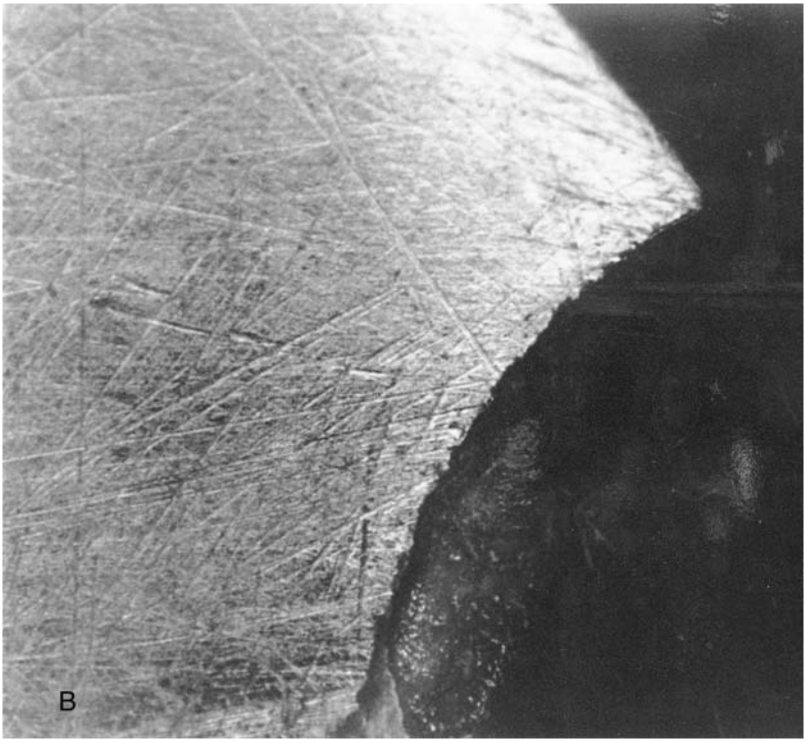

Figure 15.3 (continued)

for fingerprints should be conducted in a systematic manner. Areas most likely to have been handled by the suspect should be carefully fingerprinted. These include the rear-view mirror, steering wheel, shift lever, door handle, glove compartment, and windows. After prints have been lifted, the location, date, time, and other identifying information should be noted on the fingerprint card. Signs of forced entry should be noted. Known specimens of broken glass, chipped paint, and similar items should be collected for future comparison.

If the radio, tape deck, CD player, cellular phone, or CB radio is missing, the electrical wires should be removed for possible comparison against recovered property. The wires should be marked in a way that clearly shows which ends were originally connected to the unit (Figure 15.7).

Abandoned Vehicles

Any officer who finds or investigates an ownerless vehicle not reported as stolen should *not* drive it away or subject it to more detailed examination until informed by the driver or owner of the reason why the vehicle was standing at that place. If it is known that a serious crime has been committed, the investigation of the vehicle must be done with the utmost care and thoroughness. The investigation must be planned carefully. The basic search for evidence in and on the vehicle should be carried out in a well-sheltered place, preferably in a garage or other suitable building, because rain or snow or even strong sunlight can destroy certain evidence. The vehicle should therefore be driven or towed from the place at which it was found as soon as possible, but only after certain preliminary investigations have been carried out.

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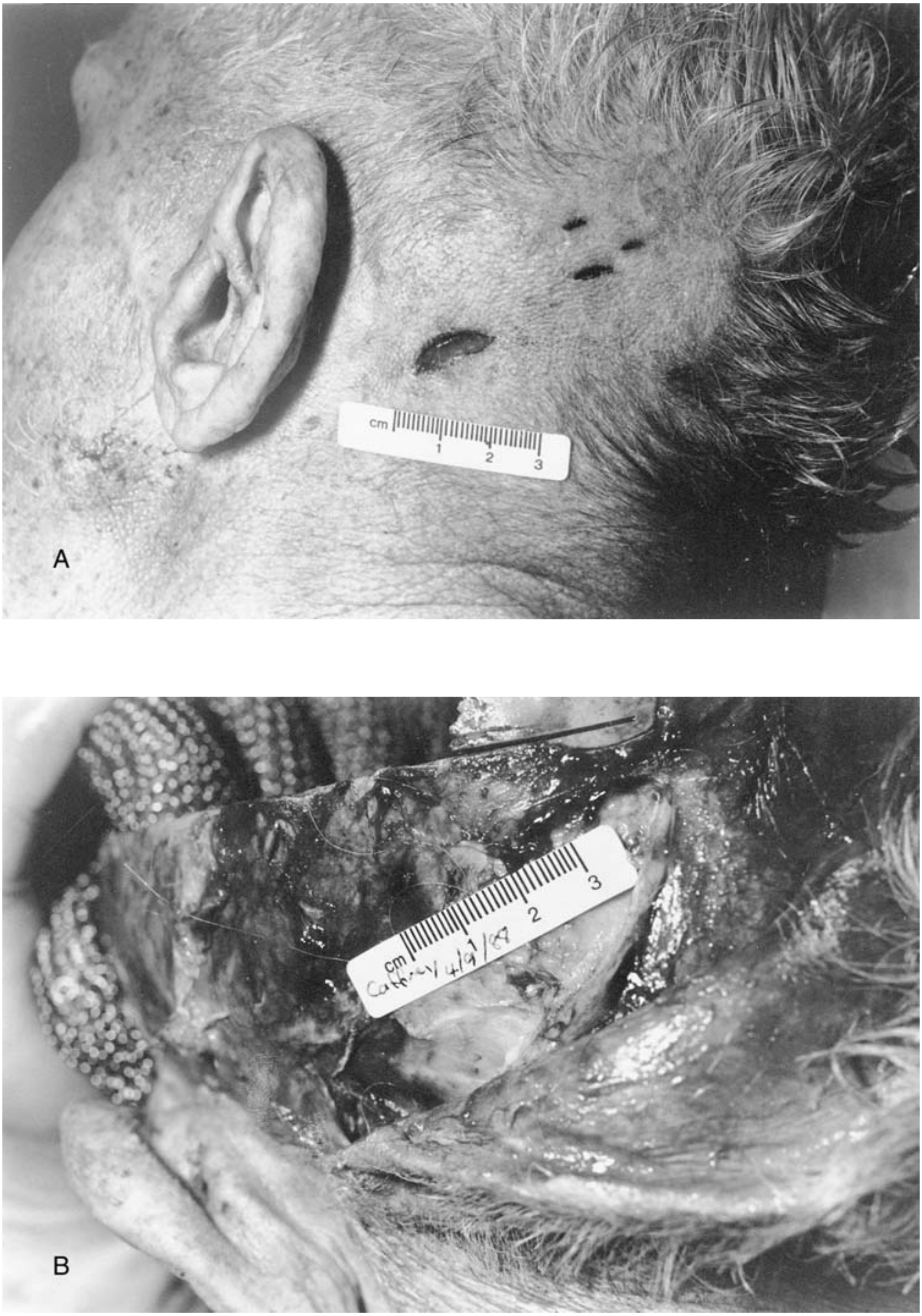

Figure 15.4 (A) At autopsy, several head wounds were noted. (B) A small metal fragment was found in the skull. (C) A close-up of the fragment. (D) A physical match of the knife blade and the metal fragment leaves little doubt that they were once whole. *(South Australia Police Department, Adelaide, South Australia.)*

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Figure 15.4 (continued)

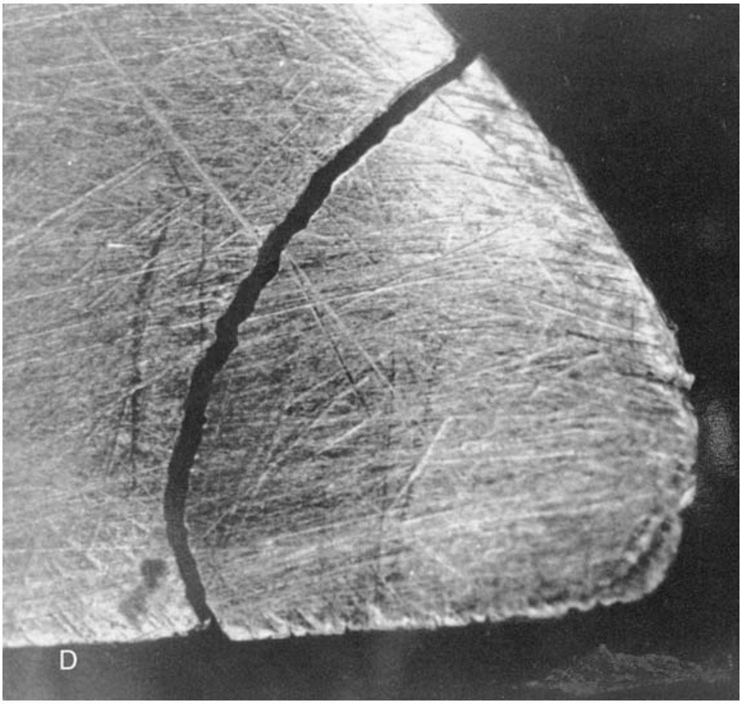

Figure 15.4 (continued)

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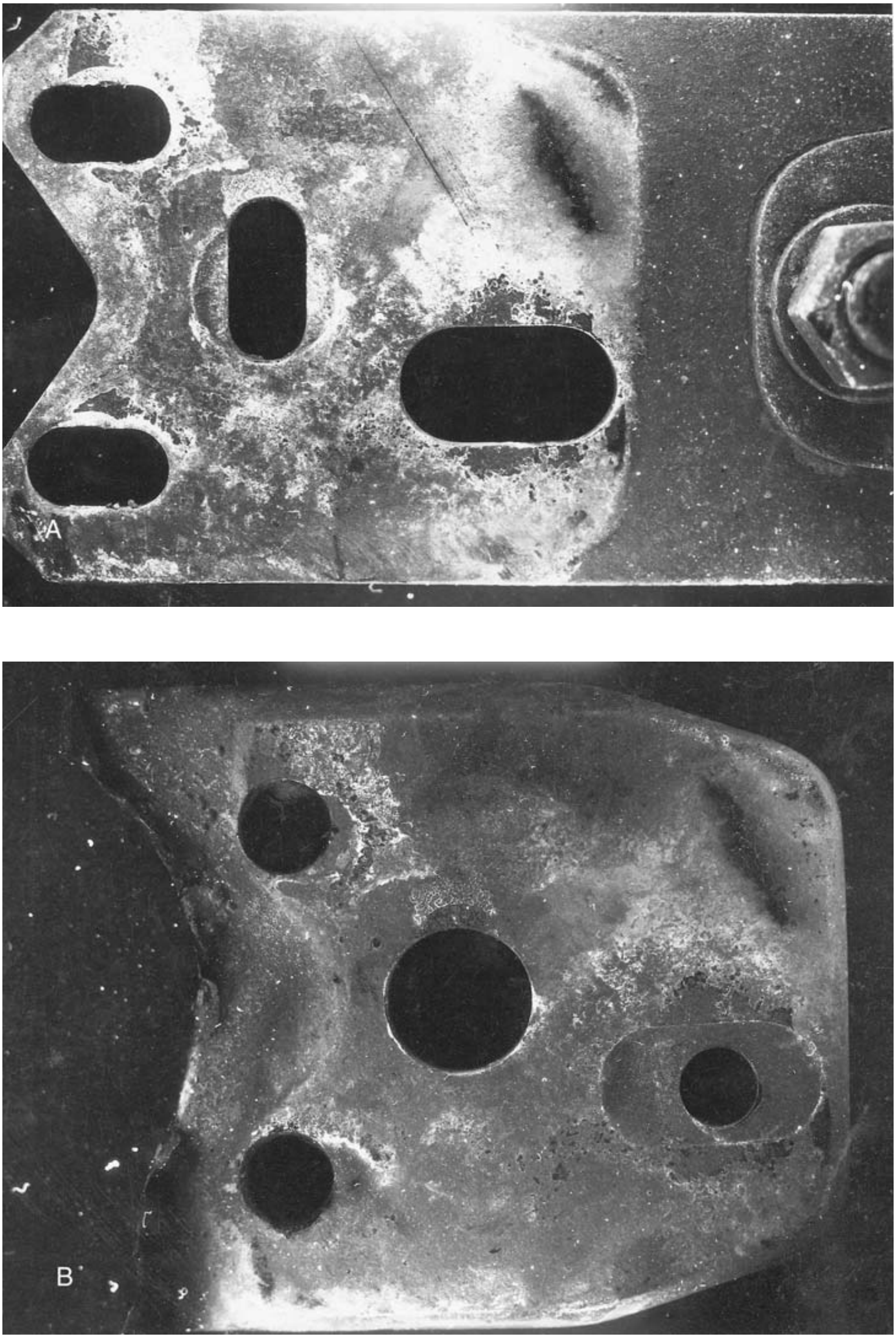

Figure 15.5 A Porsche 924 Turbo was stolen and subsequently recovered, but it was missing numerous parts. Automotive parts suspected to have been removed from the stolen Porsche were found in a suspect's possession. Examination indicated that the rear axle link mounting brackets exhibited sufficient detail for comparison purposes. The right mounting bracket from the vehicle (A) and the right axle link-mounting bracket (B) (reversed) are shown. To enhance the detail of the pattern present on the bracket, ultraviolet photography was used. *(Michigan State Police.)*

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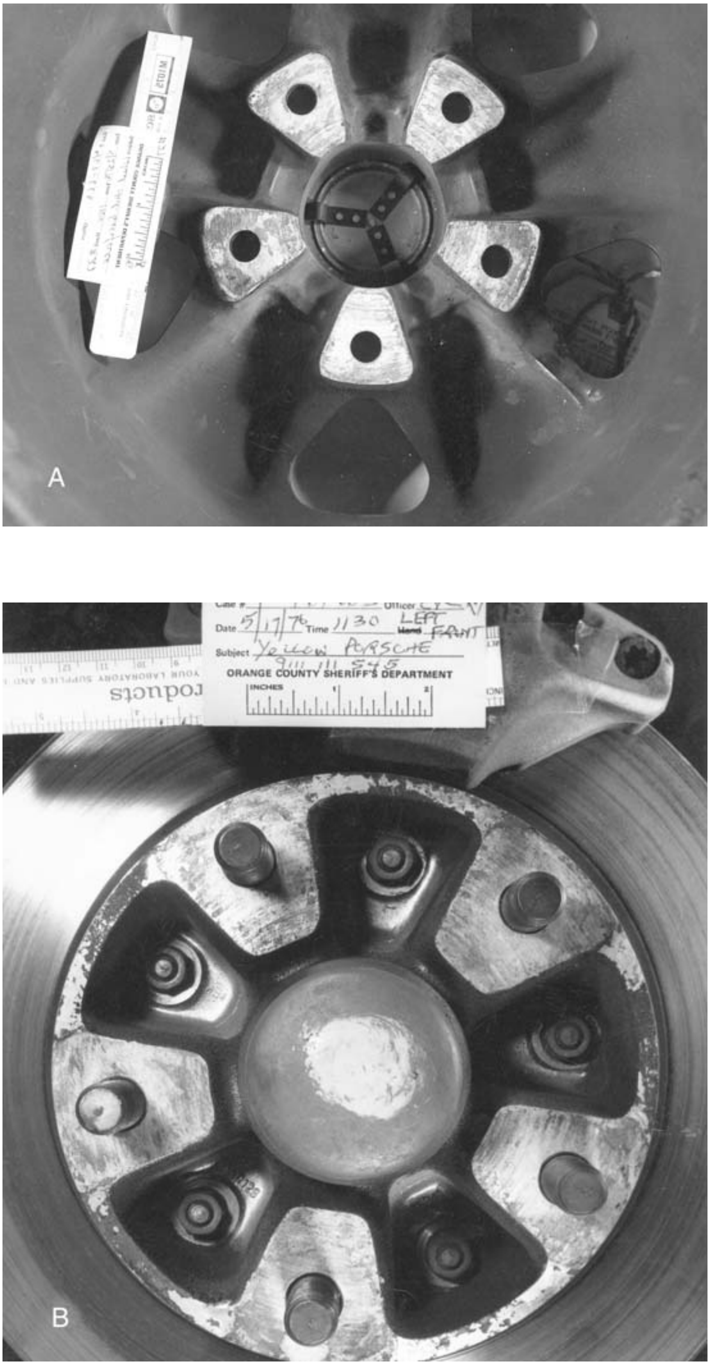

Figure 15.6 Comparison of wheels from a Porsche (A) with a corresponding mount from the victim's vehicle (B). Note that the negative has been reversed in (A). Photographs (C) and (D) show comparisons of the markings on each. *(Orange County Sheriff-Coroner, Santa Ana, California.)*

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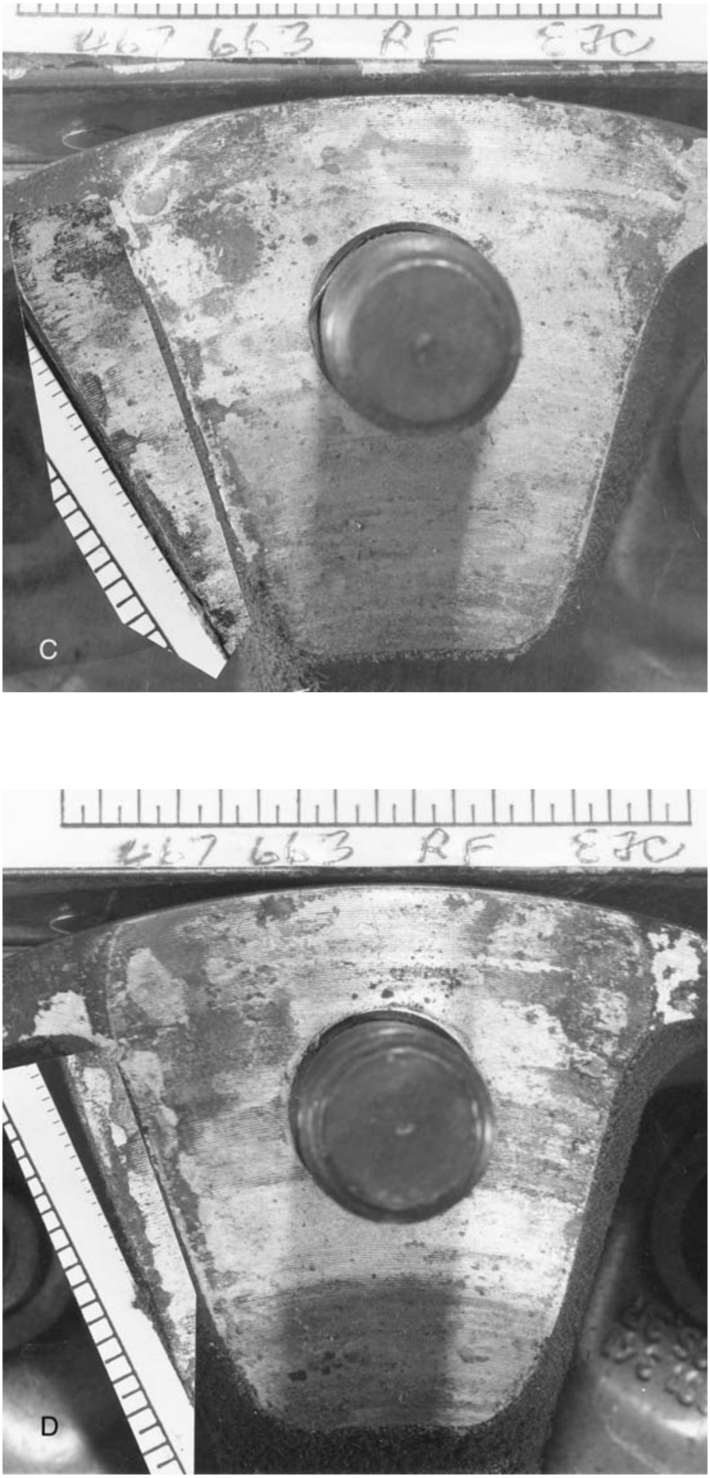

Figure 15.6 (continued)

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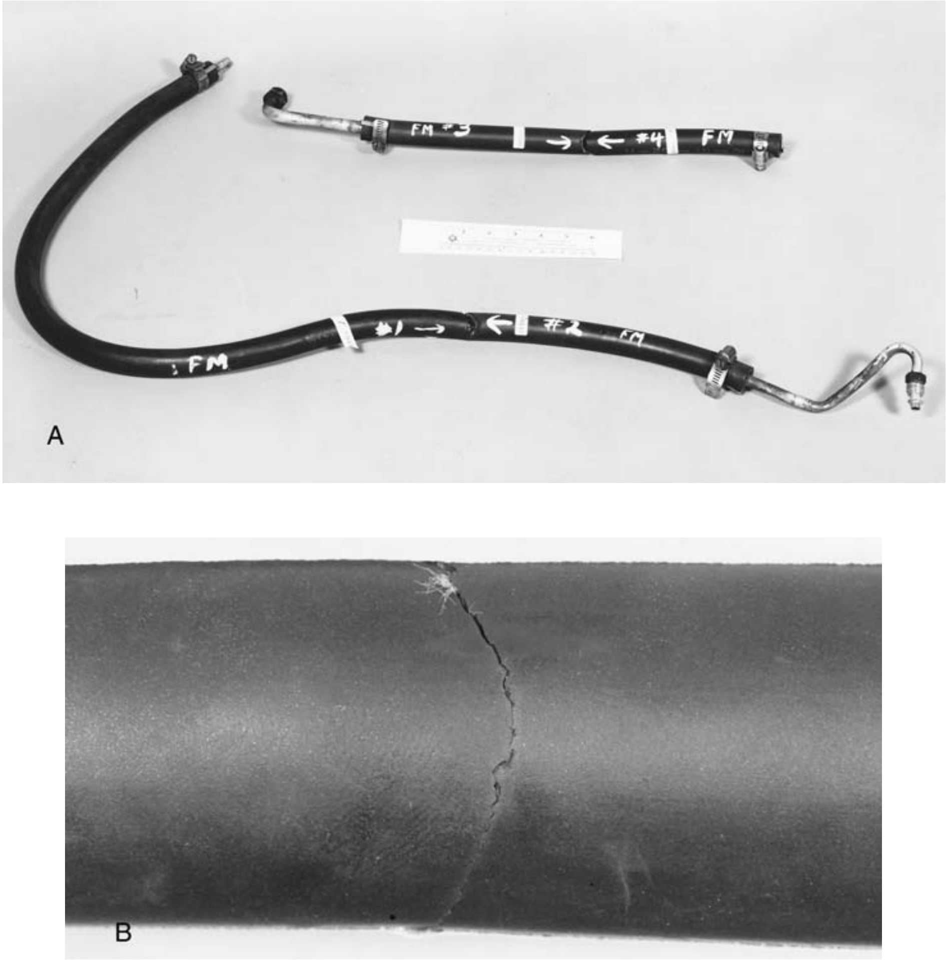

Figure 15.7 (A) Cut hoses in a vehicle theft and (B) a close-up physical match. *(Los Angeles County Sheriff's Department.)*

The place where the vehicle is found should be photographed and sketched in the usual way. Photography is done while the vehicle is still on the spot, but sketching can wait until later. In sketches, the distance to the nearest occupied dwelling and to the nearest town or city should be given. If necessary, a sketch plan may be made of the immediate surroundings, and another of neighboring districts, but suitable maps may replace the latter. The recording of the odometer or taxi meter should be noted; it is best to ask an expert whether anything of special significance can be observed. The supply of gasoline is checked. An attempt is made to determine whether the vehicle stopped at that point for some reason unforeseen by the driver, for example, engine trouble, depleted gasoline supply, inability to drive it further, and so on. The floor in front of the driving seat is examined carefully. Preferably all dust and dirt at this place should be kept. The exterior is examined for the presence of any evidence that might fall off when the vehicle is driven or towed away.

Furthermore, a preliminary examination of the whole vehicle should be made for evidence that is easy to collect or that for any reason might be damaged or destroyed when the vehicle is driven away. The detailed investigation of a vehicle should *not* be carried out

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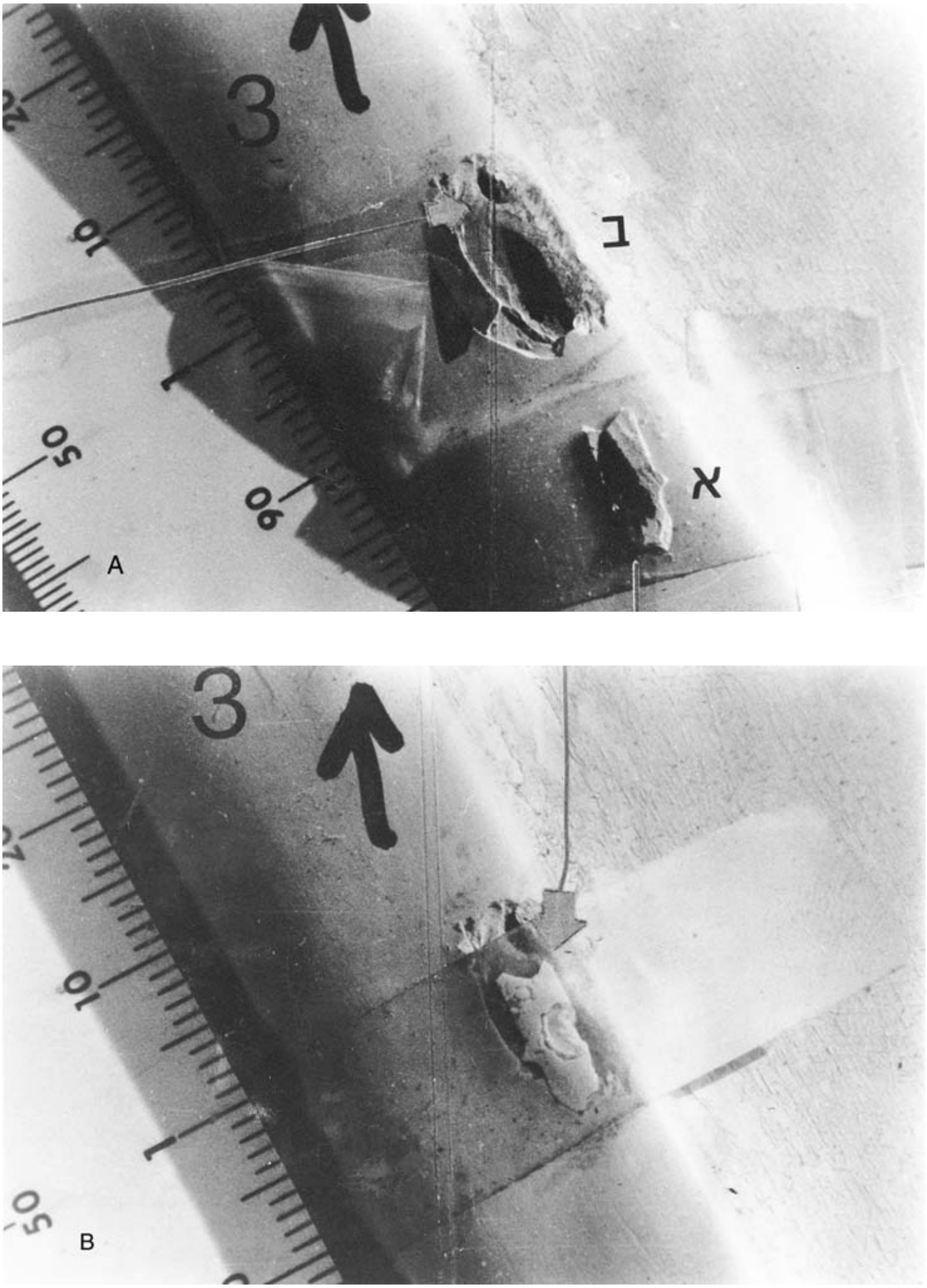

Figure 15.8 A small fragment broken from a vehicle next to the damaged area on a car fender (A) and the piece fitted into the damaged area (B) from a hit-and-run case. *(Israel National Police.)*

at the place where it is found, but the site chosen should be as near to the place of finding as possible. A long drive or tow can cause a deposit of dust or dirt that may completely destroy any possibilities of finding evidence in the form of fingerprints. Only the person who is to drive the vehicle away should sit in it, remembering not to touch any object in

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the vehicle other than what is necessary for driving. Gloves should be worn, but if any fingerprinted object is touched with a gloved hand, the print may be destroyed.

After removing the vehicle to a sheltered place, a thorough investigation is made of the location where the vehicle was found and the surrounding area. It is possible that the criminal, after committing the crime, unconsciously dropped or threw away objects that show the route taken or supply incriminating evidence. The investigation must be done quickly, especially if snow is anticipated. If larger areas or stretches of road must be searched, it may be advisable to call for a search team; however, they must first be instructed in how to act if they find any evidence. The detailed investigation of the vehicle is done only after it is completely dry.

In general, the floor of the vehicle and seats are examined first; only after this is done are any fingerprints developed. It may be convenient first to examine the outside of the vehicle in order to avoid the risk of anyone unthinkingly destroying evidence or leaving prints. The contents of ashtrays are examined and kept, with various objects noted in the order in which they occur from the top. The contents of the glove compartment and any other storage spaces are examined and noted in a similar way. In and under the seats, objects are often found that the criminal has dropped. Any bloodstains in and on the vehicle are examined for direction of fall, height of fall, direction of movement, etc., after which they are preserved. Marks of swinging a weapon, damage from gunshot, and the like are preserved. The engine and trunk are examined. In the investigation of a vehicle in which a crime of violence has been committed, it is advisable, after collecting the evidence, to take measurements of the amount of room in the vehicle. A question may arise about the possibility of a criminal swinging an instrument, handling a firearm, and other such acts. Any evidence of the vehicle's being used in any crime should be noted; safe paint and insulation in the trunk, outlines of boxes or tools, even bullet holes should be sought. All normal serial numbers should be checked in order to detect alterations in the identity of the vehicle. Any damage to the vehicle may indicate the abandonment and reported "theft" were to hide an accident. The exact condition of damage should be carefully noted and photographed.

Under suspicious circumstances, the temperature of the water in the radiator and the surrounding air temperature should be recorded. From these data, it may be possible to establish the duration of time since abandonment. A careful search of the trunk is indicated in those cases in which it carried a dead body. If the victim was killed in one location, transported in the vehicle, and dropped at another site, only a very small amount of evidence may be in the trunk. In some cases, the interior may have been cleaned to remove traces of blood. In such cases, it may be worthwhile to remove the liner to search for blood that has seeped through and was not noticed by the suspect. Removal of the seats should also be considered for a thorough search. Weapons, tools, and sometimes trace evidence that can link the victim to the vehicle may be uncovered. In cases of rape, the seat covers or the entire seat should be submitted to the laboratory for testing for the presence of seminal fluid.

Homicide in a Vehicle

Taxicab drivers are sometimes the victims of robberies, often in combination with assault that may be fatal. For a criminal who is desperate enough, it is a relatively simple matter

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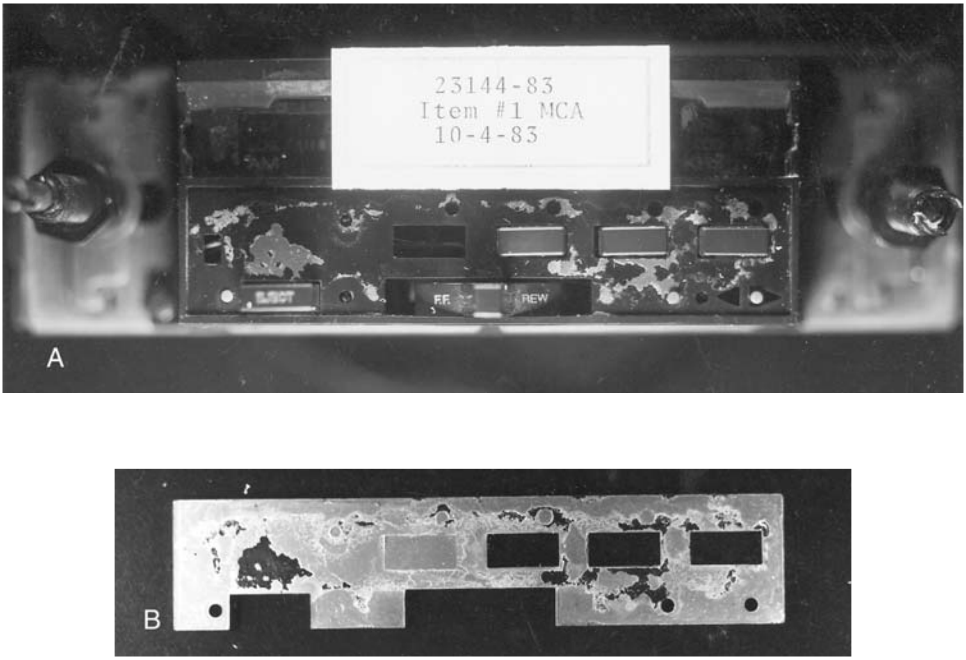

Figure 15.9 A radio stolen from a vehicle (A) and the faceplate (B) (shown reversed) left at the scene are compared and indicate a common source. *(Michigan State Police.)*

to order the driver to a desolate area, assault the driver from behind without too great a personal danger, and then rob him. Because it would be dangerous to attack the driver while the cab is moving, the driver is asked to stop under some pretext or other. After the robbery is completed it is not uncommon for the attacker to hide the victim and then drive the car as far away as possible from the scene.

In cases in which the robbery victim dies, one can expect to find the vehicle and the victim in different locations; sometimes the vehicle is found first. There is a great risk, therefore, that the examination of the vehicle is difficult or impossible because an overzealous officer has the vehicle removed, thinking that it is only a case of “joyriding.” For this reason, every officer who finds an abandoned vehicle should suspect the worst and exercise extreme care. After a license check has revealed that the vehicle may have been the scene of a crime, the procedure suggested in the section “Abandoned Vehicles” should be followed, as well as the procedure for the specific type of crime. The search of a vehicle in which a homicide was committed must be conducted with the same degree of care as would be used in conducting the search of an indoor or outdoor crime scene involving a murder. Because of the cramped working area, it is especially important to exercise care so as not to destroy any physical evidence in the vehicle. The procedures discussed elsewhere in the text for processing the crime scene are generally the same for a vehicle.

Cases involving sabotage or acts of terrorism in which the vehicle was blown up by an explosive charge require a thorough investigation to recover as many parts of the device as possible. The debris from the explosion may cover a wide area, and a careful and systematic search is necessary to locate, chart, and recover as many pieces of the damaged vehicle and bomb as possible. Pieces of a timing mechanism, electrical devices, wires, and batteries, as well as explosives residue, may prove to be valuable evidence in the investigation.

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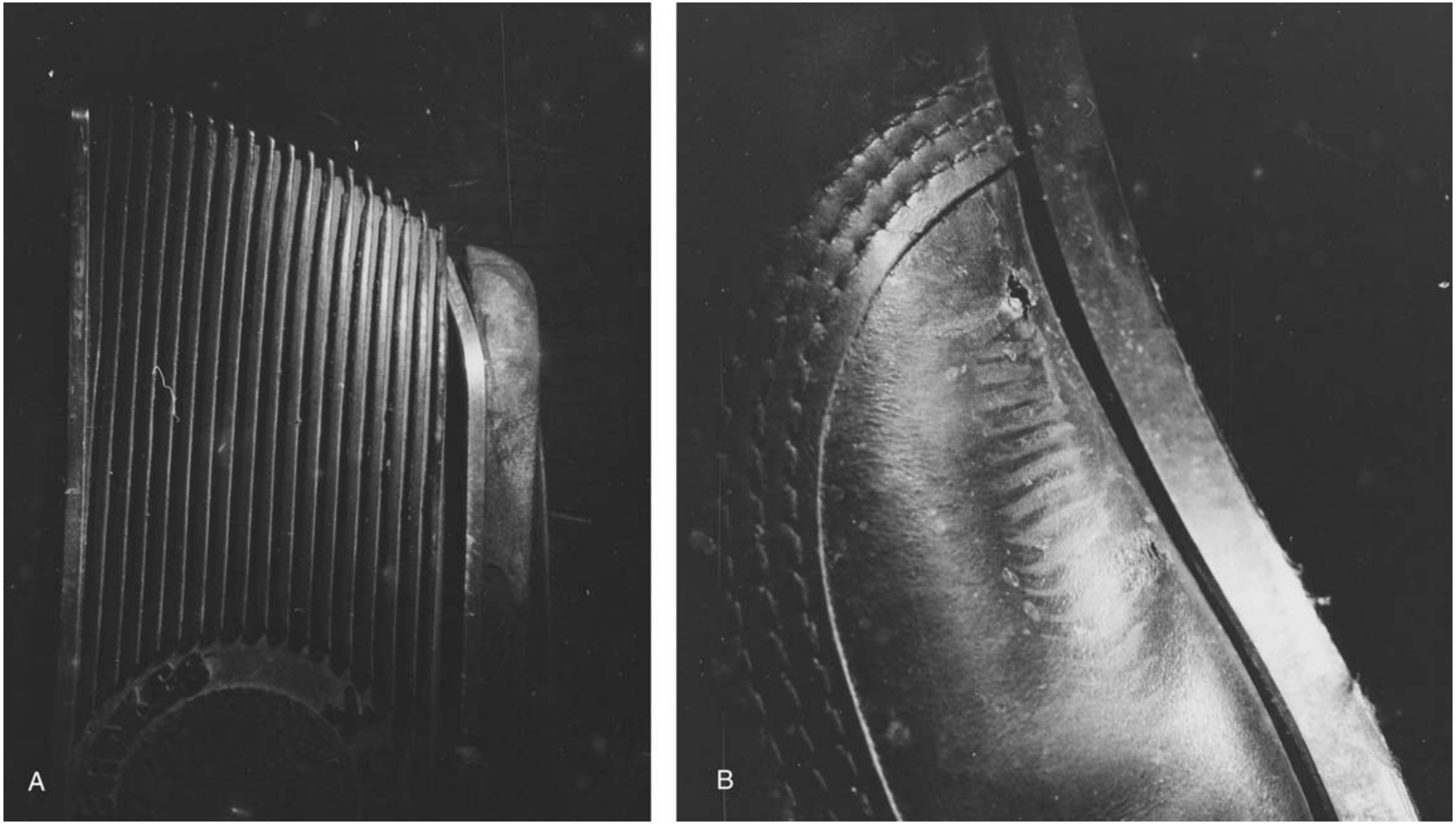

Figure 15.10 A car that left the road struck a bridge abutment and threw a woman from the vehicle to her death. The officer arriving on the scene found a man unconscious in the back seat. The subject refused to identify the driver of the vehicle. The investigating officer submitted both of the man's shoes, as well as the brake and gas pedals, hoping the laboratory could find a pedal impression on the left side and a puncture mark in the leather. These striations matched the 18 rubber ribs on the brake pedal (A) and the puncture matched the location and size of the bottom banding wire from the bottom of the pedal, which was bent outward. The subject was subsequently convicted of vehicular homicide. *(Ohio State Highway Patrol.)*

Figure 15.11 An investigator submitted a speedometer head to determine the speed of a vehicle at the time of impact. The speedometer dial was examined under ultraviolet light, and a "speed mark" was detected in the area of 20 MPH. This speed mark is an imprint of the speedometer pointer (needle) on the dial caused by the force of inertia at the time of impact. *(Forensic Laboratory, Office of Attorney General, Pierre, South Dakota.)*

Hit-and-Run Investigation

Hit-and-run cases include two types: damage to other vehicles or property and death or injury to individuals. In both cases, physical evidence can assist in identifying the hit-and-run vehicle, establishing a connection between the vehicle and the victim or crime scene, and reconstructing the scene in general to determine the events surrounding the crime. Cases involving damage to other vehicles are often the result of driving under the influence or in a careless or reckless manner. The usual types of physical evidence found at the scene are paint chips or scrapings, glass, pieces of headlamps or plastic reflectors, and pieces from the grillwork of the vehicle. Most of these items are very small and therefore easily overlooked when searching the crime scene. Also, the impact from the crash may throw certain items some distance from the vehicle and loose or broken parts still attached to the hit-and-run vehicle may subsequently fall off at considerable distance from the scene. These considerations make a search of a greater area important in these cases.

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The hit-and-run crime scene often has a factor not present at other scenes: traffic. If the fatality occurred in a busy intersection or on a well-traveled street, the officer may feel pressured to complete the investigation more quickly. Although time may be a consideration, it should not deter the investigator from doing a thorough and complete job of processing the scene. Overall crime scene photos should be taken as well as photographs from different views. Close-up photographs of the victim as well as of items of physical evidence must be taken. If the crime occurred at night, portable lighting should be brought in so that the area is adequately lit. The area should be examined for tire impressions and particularly for skid marks, which can be used to determine the direction and speed of the suspect vehicle and therefore are important in the case.

Trace items of evidence present on the victim's body are also important. Care must be taken when moving the deceased so as not to lose valuable trace evidence. When the deceased is brought to the morgue, clothing should be carefully searched for paint, glass, and other parts from the suspect's vehicle. These items should be packaged, tagged, and submitted to the crime laboratory for examination. If the victim was on a bicycle or motorcycle, it should be carefully examined. Various types of trace evidence, such as paint, may be present that can be used to tie the suspect vehicle to the crime. Lights from the victim's vehicle should be recovered and submitted to the laboratory to determine if they were operational and whether they were on or off. Clumps of soil or dirt found at the scene should be documented and collected. These can be compared with dirt found on the undercarriage of the suspect's vehicle and may demonstrate a connection.

The scene should be examined for specific damage to the unknown vehicle. Broken parts of the vehicle should be collected for possible physical matching. In certain cases, the vehicle's make and sometimes the model can be determined by these parts. This information may be helpful if the investigator contacts automobile repair body shops or parts stores to determine if anyone recently came in to have a vehicle repaired. Occasionally, the force of impact is so great that impressions from the vehicle are made on the victim's body or clothing. Such evidence should be photographed and preserved for later comparison (Figure 15.12). Paint chips are especially important items of physical evidence. If they are sufficiently large chips, it is possible to fit them physically into the vehicle in jigsaw puzzle fashion. Paint will, at a minimum, be useful to determine the color of the hit-and-run vehicle, and in some instances the make of the vehicle can be determined through laboratory examination. Further, physical and chemical comparisons of paint recovered at the scene can sometimes be made with that from the suspect's vehicle.

As part of the autopsy procedure, specimens of the victim's blood and hair should be collected for later testing. A toxicological sample of blood should be taken to determine whether the victim was under the influence of alcohol or other drugs and for determining blood type. Clothing, as mentioned before, should be retained for fabric and fiber exemplars in addition to examining for patterns and other traces present. Once the suspected vehicle is found it should be taken off the road to a nearby place for examination.

When the vehicle is first found, if any evidence or obviously damaged areas are noted that might be lost in moving the vehicle to a garage, then they should first be collected. If the owner of the vehicle claims that the car had been stolen, fingerprint examination is especially important to help prove or disprove this contention. The exterior of the vehicle should be thoroughly searched, including the undercarriage. The vehicle should be placed on a hydraulic lift to facilitate this examination. Evidence such as hair, blood, skin, and fabric and fiber evidence may be located there. Specimens of grease and dirt should be

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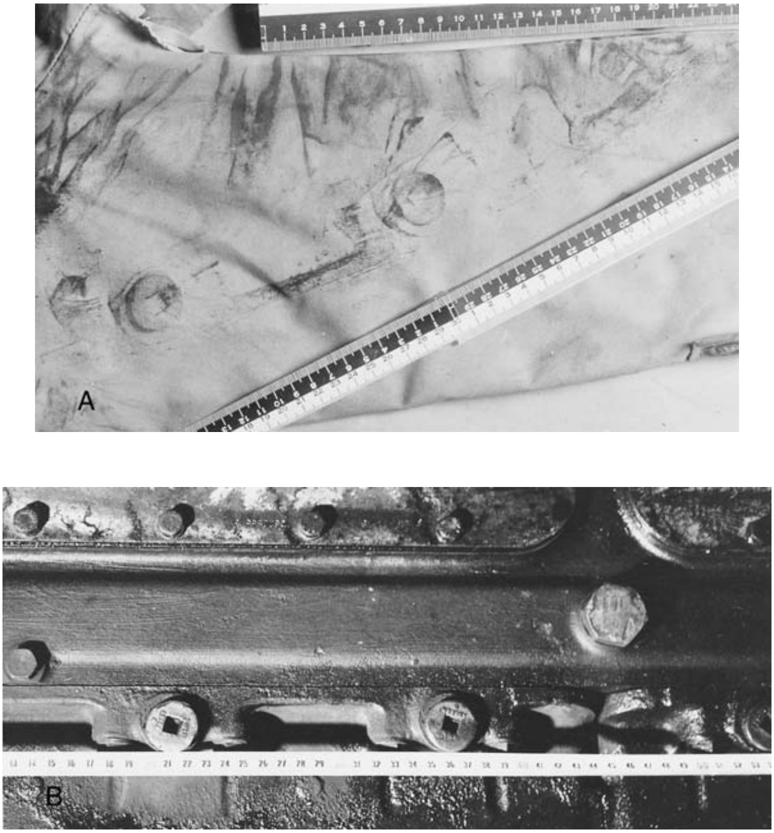

Figure 15.12 Various imprints and impressions, including round and hexagonal marks found on a victim's coat from a traffic accident (A). The suspected bus driver denied hitting the victim; however, examination of the bus's underside (B) determined that part of the oil sump could have made the marks. Because several buses had passed the location, they were brought into a garage and the sumps of each were examined and photographed. A random sample of additional buses was also examined. Because the bolt orientations were shown to be unique, the conclusion was made that the suspect bus caused the imprints. *(Israel National Police.)*

collected for comparison with debris found on the victim. The front area of the vehicle and the hood should be thoroughly examined. Occasionally, fabric impressions from the impact appear in the dust on the bumper. These should be carefully photographed with a scale and if possible the bumper or fender should be removed and submitted to the laboratory. All broken parts and damage to the vehicle are important items of evidence. Damage to the front end such as broken grills, headlights, scratched paint, other scratches, and other damage are to be carefully noted and, if possible, removed and submitted to the laboratory. In some instances, evidence from the motorcycle or bicycle that the vehicle hit may be present; these items should be preserved.

Known specimens from the hit-and-run vehicle should be collected. These especially include paint that should be collected in the area of any damage to the vehicle. If scrapes containing other paint material are noted, these too should be collected to be compared with the victim's vehicle. In some cases the victim may have been hit and thrown onto the vehicle hood or windshield. Fingerprints belonging to the victim as well as hairs, fibers, and blood should be searched for with this in mind. If the windshield is broken, glass

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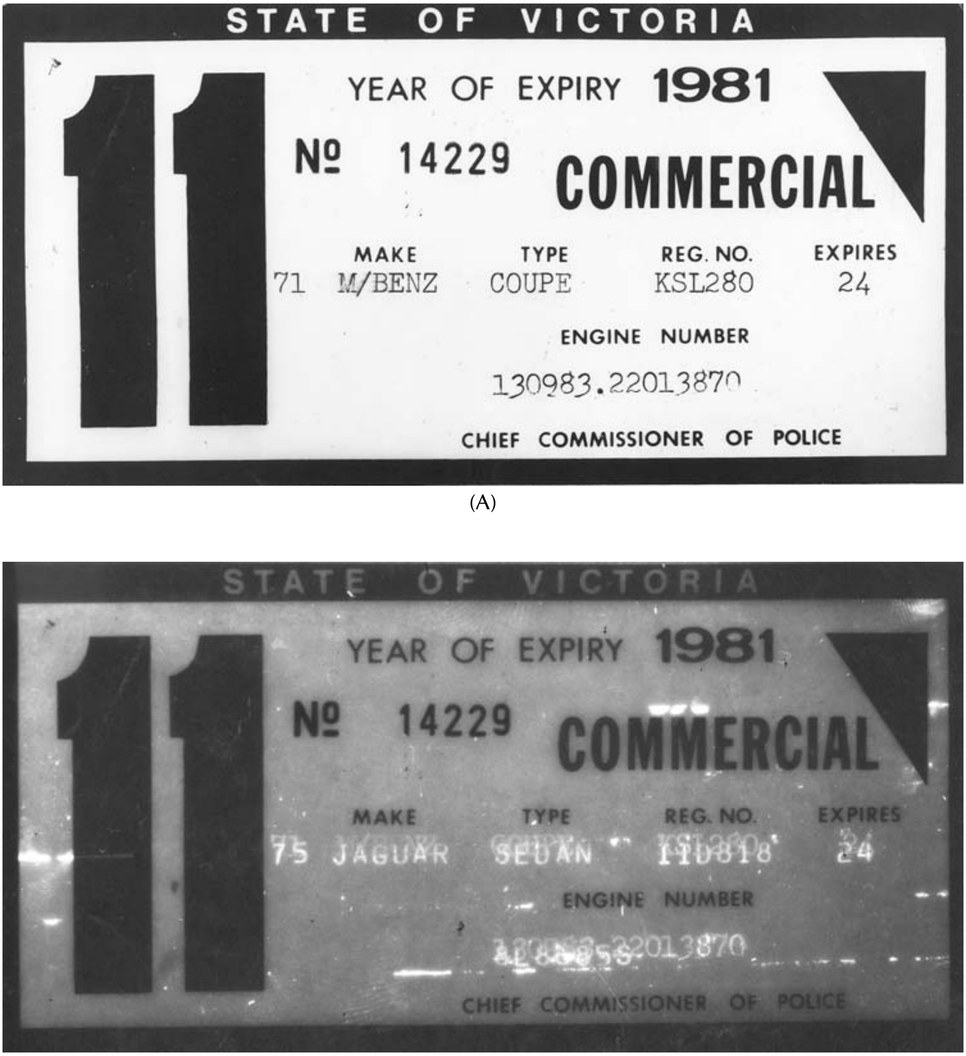

STATE OF VICTORIA

11

YEAR OF EXPIRY 1981

№ 14229 COMMERCIAL

MAKE	TYPE	REG. NO.	EXPIRES
71 M/BENZ	COUPE	KSL280	24

ENGINE NUMBER

130983.22013870

CHIEF COMMISSIONER OF POLICE

(A)

STATE OF VICTORIA

11

YEAR OF EXPIRY 1981

№ 14229 COMMERCIAL

MAKE	TYPE	REG. NO.	EXPIRES
75 JAGUAR	SEDAN		24

ENGINE NUMBER

22013870

CHIEF COMMISSIONER OF POLICE

(B)

Figure 15.13 An altered registration document viewed under (A) visible light and (B) infrared light, showing the obvious fabrication. *(Victoria State Police Forensic Science Laboratory, Melbourne, Australia.)*

should be collected and a search made for hairs and blood. Headlamps and tail lights should be examined to determine whether they work and, if possible, they should be sent to the laboratory. Examination of the filament can determine if the lights were on or off at the time of impact. Broken headlamp lenses and signal light reflectors should be removed for comparison with evidence collected at the scene. Sometimes it is possible to make a physical match with these items.

Case

During a sailboat race on Lake Ontario, one boat was struck by lightning. The crew radioed to the race organizer that they were dropping out of the race and

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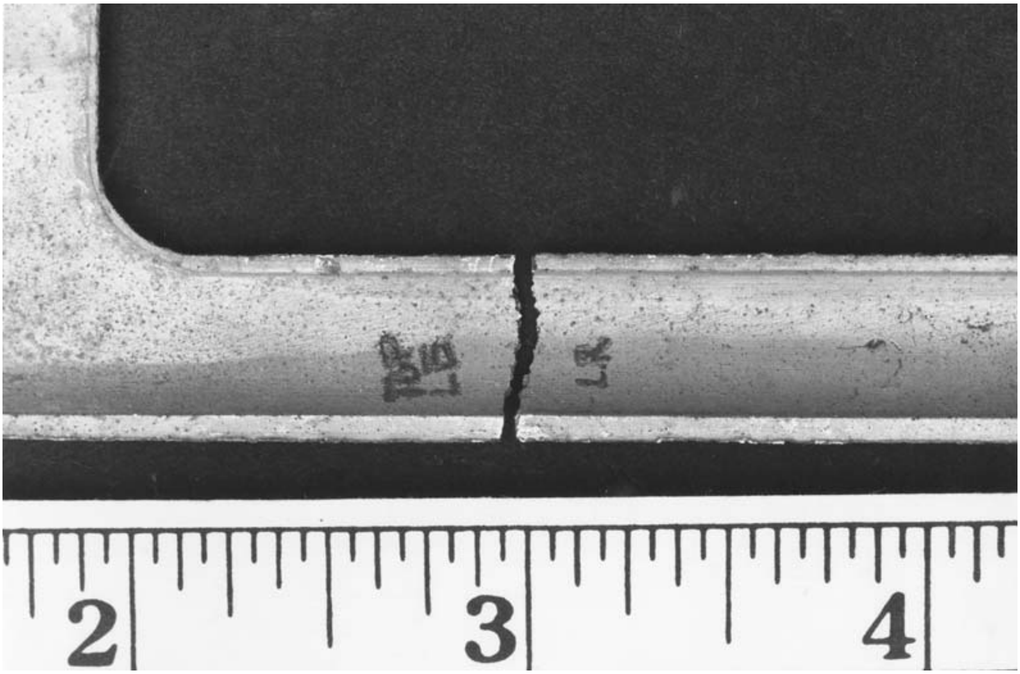

Figure 15.14 (A color version of this figure follows page 256.) This close-up photograph of a physical match of broken pieces of a license plate holder proved a vehicle was associated with a hit-and-run incident. *(Los Angeles County Sheriff's Department.)*

heading for Rochester, New York; this was the last contact with them. No SOS and no search for the boat were undertaken. Three days later, an American fisherman found two bodies (tied together) floating with a beacon light attached to one of them. The beacon was lit at the time of the discovery. When the beacon later came into possession of Canadian authorities, the bulb was burned out. At the inquest, there was apparently conflicting evidence: the type of light bulb (no.13) used can only last for approximately 2 hours with a set of new batteries. Thus, if the fisherman found the beacon lit, the boat must have capsized only hours before the bodies were discovered. The examining pathologist from the U.S. determined the bodies had been dead approximately 70 hours. Scanning electron microscopic (SEM) examination of the filament discovered two breaks, both while the bulb was hot (ON) — an indication that the bulb had a "second life." The conflicting evidence can be explained with the bulb's "two lives" (although it is not proof). In the case of the very fine filament in the lamp, the SEM has a considerable advantage over conventional microscopes in demonstrating the breaks and re-established contact by providing a clear photograph with good depth of focus and a reflection-free image (Figure 15.15).

If tire impressions were made at the scene, photographs containing a scale should be made of each tire. Inked tire impressions on paper can be made for comparison with tire impressions located at the crime scene. If the suspect driver is apprehended soon after the hit-and-run incident, a blood sample should be obtained. The sample should be submitted

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to the laboratory for testing for alcohol or other drugs to determine if the suspect was under the influence.

Marks from Vehicles

Vehicle marks are composed of tracks of wheels or runners. In a specific case, there may also be an indication of a particular type of load, for example, slipping branches in a load of wood or ends of logs in a load of lumber, the smell of fuel oil or lubricating oil, etc.

Wheel Marks

With the aid of wheel marks, direction of movement can be determined. When the ground is damp, the underlayer on which the wheel rolls forward is compressed and the bottom of the mark is formed as a series of steps. The compressed clods of earth in the mark are lifted in the same direction as the wheel is rolling. To assist the memory in this respect, it is easy to remember this rule: for the mark to become level again, the wheel must roll in the opposite direction. A vehicle that travels in a straight line actually leaves only the track of the rear wheels; to observe marks of the front wheels, it is necessary to find some place where the vehicle has turned sharply or reversed.

In examining wheel marks, it is necessary to look for places showing defects or repairs in the tires. With the aid of successive marks of this type, the circumference of the tire can be determined. The track is measured between the center points of the two wheel marks.

Preservation is achieved by photography and casting selected points showing characteristic marks or wear. When photographing, a scale is placed across the track and another along one side of it. Casting is done in the same way as for foot impressions (discussed in Chapter 9). In examining vehicle marks, it should be noted whether wheels that follow one another go in the same track or whether there is any deviation. If dual wheels are found, both tread marks should be recorded simultaneously because the relationship of one tread pattern to the other provides additional characteristics for identification of the vehicle.

Skid Marks

The speed of the suspect vehicle at the time of impact is sometimes at issue. If skid marks are present at the scene, a traffic officer with training in skid mark interpretation should be contacted and requested at the scene. Based upon factors such as the length of the mark and the coefficient of friction of the road surface, an approximation of the speed at which the suspect vehicle traveled may be calculated.

Investigations involving motor vehicles occur in many cases, such as vehicle thefts, abandoned vehicles, homicides, hit-and-run investigations, and so on. Physical evidence consisting of fingerprints, tool marks, glass, paint, fabric impressions, tire marks, physiological fluids, hairs, fibers, and the like should be carefully searched for, collected, and documented as in all crime scene investigations.

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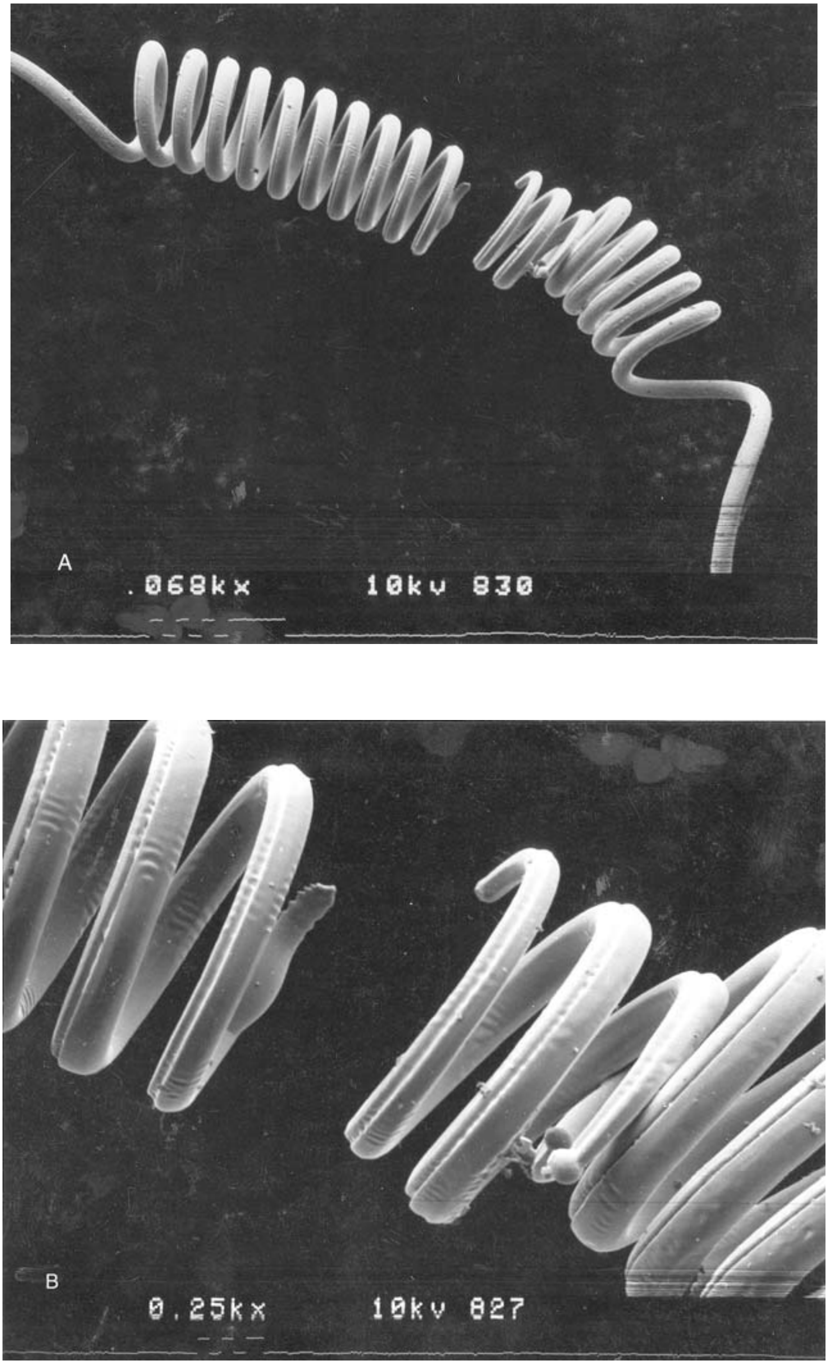

Figure 15.15 Although this case is not about motor vehicle investigations per se, it illustrates the examination of lamp filaments. (A) A scanning electron microscope photomicrograph of a lamp filament showing that there had been a break that reconnected and then a second break. (B) A close-up of the same filament. *(Centre of Forensic Science, Toronto, Ontario.)*

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Homicide Investigation

16

Of all major crimes, homicide investigation requires the greatest effort on the part of the police. The investigator is responsible for collecting a vast amount of evidence and coordinating information from a variety of sources including the witnesses, suspect, officers involved with the crime scene, forensic pathologist, and criminalist. Death investigation requires a team effort; only through cooperation of persons from many disciplines, coordination of efforts, and meticulous attention to detail can a successful conclusion of an investigation be realized. This chapter brings together many of the concepts discussed previously in the text and examines areas unique to the investigation of death.

The finding of a dead body is the starting point and initial focus of the death investigation. The rules for the first officer to arrive at the crime scene are the same as outlined in earlier chapters. The first officer to arrive is required to determine if the victim is dead and, if so, to notify the homicide investigators. Determination of suspicious death at this point is critical. In many cases the first officer to arrive at the scene has erred and pronounced the death to be from natural causes, only to learn at a later time that the cause of death was the result of an unnoticed bullet wound. The point is that care and attention to detail are critical in this type of case.

Once the investigation has begun, the investigator should attempt to find and collect all evidence that may be used in the case. Even items that may seem unimportant and of no value should be considered potential evidence. In murder investigations, there is usually an abundance of evidence even in those cases in which the suspect has attempted to clean up after the crime. Even in a so-called "perfect murder," there will be much evidence to aid in the crime's solution. In fact, there is no perfect murder — only cases in which a deliberate killing could not be proved.

In the majority of cases, it is not difficult to determine that the suspicious death was the result of a murder rather than a suicide or accident. More difficult are those cases that, at first appearance, seem to be an accident or suicide. In those cases, the first officer and investigator must be thoroughly familiar with all aspects of homicide investigation. The initial analysis of the situation and the evaluation of the case require at least as much knowledge as the subsequent investigation of the crime scene.

The officer should keep in mind that if a supposed suicide is judged to be a murder, a serious error has not been committed, even though the investigation may become more extensive than is necessary. If, on the other hand, a murder is judged a suicide, the officer has not only failed in the investigation but may also have made the solution of the crime and the apprehension of the killer more difficult, if not impossible.

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Murder, Suicide, or Accident?

When evaluating whether the deceased died from an accident or suicide, or if death was caused by another person, it is generally best to suspect the worst — murder. Even if circumstances give the overwhelming appearance of suicide or accident, the investigation should be conducted in as much detail as possible. Murderers have been known to intentionally make the death appear to be an accident or suicide. The investigating officer must be aware of this possibility. Only through systematic and accurate investigation can a deception be revealed as that of homicidal intent.

When investigating cases of sudden death, the officer should attempt to evaluate the circumstances revealed at the crime scene as quickly as possible. The following questions should be answered immediately: What was the cause of death? Could the deceased have produced the injuries or brought about the circumstances that caused the death? Are there any signs of a struggle? Where is the weapon, instrument, or object that caused the injuries, or traces of the medium that caused death? Although these are only four of many questions that will arise in death investigation, they are probably the most important ones for guiding the continued investigation.

Cause of Death

The first question the officer is required to answer is: what was the *cause of death*? It should be noted here that the determination of the cause of death at this time is the *apparent* cause of death and not the *actual* cause of death to be determined by the medical examiner through an autopsy. Determining the cause of death, whether it involves stabbing, shooting, strangulation, or other means, represents a starting point for the investigator and helps him to begin putting the facts and circumstances behind the death into focus.

In evaluating the cause of death, it is very useful for the investigating officer to have a good knowledge of the appearance of different types of injuries and wounds. The investigator is not expected to have the same expertise in this area as that of the forensic pathologist, but he or she must have at least a working knowledge of the subject in order to take the initial steps of the death investigation. An erroneous estimate of the cause of death may lead the investigation in a wrong direction and may even jeopardize the ultimate solution of the crime. For example, if an inexperienced officer mistakes a gunshot injury for a stab wound, the entire investigation may be sidetracked.

The officer should not confuse experience with expertise, for it is the province of the pathologist to determine the cause of death, no matter how much experience the investigator has. On the other hand, the officer's primary duty should be to keep in mind that success is usually the result of cooperation and teamwork between the medical examiner and the homicide investigator.

Suicide

Could the deceased have produced the injuries or brought about the effect that caused death? A determination of whether death was the result of suicide or murder is extremely important in the initial phase of the investigation. Usually the decision is based upon an

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Figure 16.1 (A color version of this figure follows page 256.) A body was dumped in a wooded area. By the time it was discovered (about 24 hours after the killing), animals had already attacked and eaten a significant amount of it. *(Los Angeles County Sheriff's Department.)*

evaluation of the injuries that resulted in the death and other factors about the deceased's mental and emotional state prior to the death (Figure 16.2).

The common modes of death by suicide are drowning, hanging, shooting, poisoning, jumping from heights, cutting arteries, stabbing, and strangulation. These factors must be considered along with the physical and psychological ability of the deceased to accomplish the act.

A detailed examination of the crime scene should be undertaken to determine if the facts are consistent with the theory of suicide. For example, it is reasonable to expect the means of death, such as a weapon or poison, to be close at hand and in proximity to the body. Failure to discover a weapon in the case of a suspected suicide makes that possibility unrealistic.

The nature and position of the injuries are useful considerations in drawing a conclusion. Hesitation marks are quite common in suicide cases involving slashing of the wrists. Similarly, gunpowder tattooing located around a gunshot wound is consistent with the firing of a weapon at close range. Such facts would be consistent with suicide. Defense wounds, however, are not expected to be found on the hands or arms of a suspected suicide.

Wound location should be considered. The wound location should be within reach of the deceased, in the case of stabbing or cutting, generally on the wrists, neck, abdomen,

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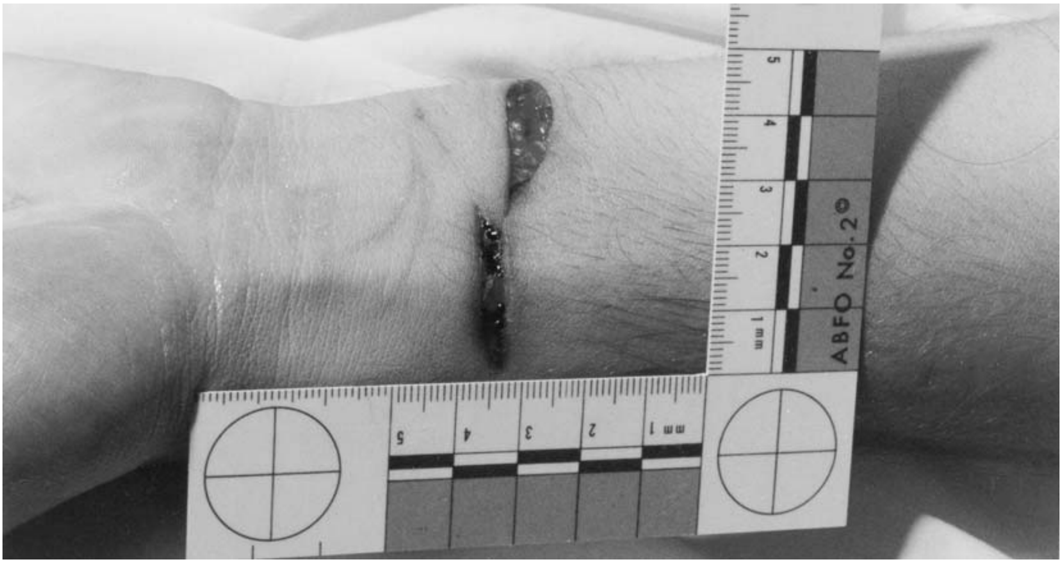

Figure 16.2 Investigators need to be able to distinguish between defense wounds and hesitation marks in a case of suicide. This is an example of the latter. *(Los Angeles County Coroner's Department.)*

or chest. A wound to the back of the head would therefore raise suspicion. Also, wounds are generally grouped in one area, as in the case of hesitation marks on the wrist.

In suicides involving handguns, the victim usually drops the weapon or throws it up to several feet away when the arms are flung outward. In such cases the floor or ground should be examined for dents or scratches resulting from the impact. Occasionally, the weapon is found in the victim's hand, but this is usually due to the gun or hand having been supported in some way at the moment of discharge.

No blood on the insides of the hands or on the corresponding parts of the gun grip and the rest of the hand blood-soaked is usually a good indication that the victim fired the shot. The same condition applies to knife handles when the victim causes the slashes. Bloodstains on the palm of the hand and the grip of the gun do not necessarily indicate murder. However, there is reason to be suspicious if the blood marks on the hand and grip do not match. In some cases a murderer has placed a gun in the victim's hand after rigidity has set in.

Someone found dead in a room in which the door is locked from the inside is usually considered to be a case of suicide or natural death. The crime scene investigator should not, however, be satisfied with this simple conclusion. Because there are methods by which doors, windows, or other openings can be "locked" from the outside, the investigator should pay particular attention to unusual traces and marks on doors, locks, latches, windows, etc.

Suicide by jumping from buildings is not uncommon in large cities. The body may land at some considerable distance from the perpendicular. For example, in a jump from an 80-foot vertical cliff, the body was found 42 feet from the base. This circumstance may seem suspicious, but it is explained by the fact that the force of an outward jump continues to act on the falling body.

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A determination of suicide should also be based on interviews with the deceased's relatives and friends and on information from a physician or psychologist under whose care the victim may have been. Instances in which the individual had a history of suicide threats or suicidal tendencies are, of course, significant to the investigation. A careful and thorough search for a suicide note at the crime scene, as well as at the victim's residence and workplace, is particularly important. Although such notes are frequently found in plain view, usually near the body, the note may have been written earlier and left in another location. In some instances, several notes have been written and placed around the house or even mailed to friends or relatives. The note should be examined by a document examiner to verify its authenticity. The investigator should collect known handwriting exemplars for this purpose and search for the writing instrument and paper used. The document should also be examined for latent fingerprints.

Motives for suicide should be considered. A terminal illness may prompt an individual to take his life so the investigator should gather information from the deceased's physician, prescriptions, medical records, etc. Poor financial situations may also be a cause and an investigation of the person's finances and debts should be undertaken. Other motives such as marital or family problems and psychological problems must also be investigated.

In cases of mental disorder, it is not uncommon that killing family members precedes the suicide. These cases must be investigated as thoroughly as other homicides. If the killer in such an instance survives an attempted suicide, it will be necessary to produce evidence about the mental state of the defendant. Psychiatric evaluation of the defendant may be considerably influenced by the findings at the crime scene. Even if the suicide victim does not survive, the investigation must be conducted with care. Inheritance and insurance matters will be influenced by the order in which the victims died.

Cases of suicide in which none of the commonly accepted motivations is apparent — even after some investigation — do occur. The opinions of relatives or friends of the deceased who are reluctant to accept the fact of suicide should not unduly influence the investigator. In many cases, the motivations for suicide are so deeply hidden that they may remain a mystery forever.

Signs of Struggle

If obvious signs of a struggle are found at the scene of a death, the case may be decided from the start as one of death by violence by the action of another person. In a room, the signs of a struggle generally consist of bloodstains, pulled-out hair, overturned or displaced articles of furniture, rumpled rugs, marks of weapons, and injuries caused by the deceased in self-defense.

Signs of a struggle show most clearly when an injured victim retreated or when an attempt was made to avoid the attack. From the visible signs, the course of events can usually be reconstructed accurately. Bloodstains can be considered the best clues for the reconstruction of the course of events in a case of murder. Generally, no bloodstains are produced during the first stage of the attack before bleeding has commenced. If victims do not immediately become unconscious at the first blow, stab, cut, or shot, it can nearly always be assumed that their hands will become covered with blood from touching the injured parts of their body. If victims attempt to escape or resist, their blood-covered hands leave marks that often indicate their position in certain situations. After a struggle in a

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Figure 16.3 (A) A team of hazardous material specialists, crime scene investigators, and detectives responded to an apartment complex to investigate a murder–suicide. Levels of hydrogen cyanide gas in the apartment were such that crime scene personnel wore protective clothing and self-contained breathing apparatuses. (B) The principal crime scene was the bathroom of the apartment. Two persons were found dead. A male (who worked as a fumigator) was located by the toilet and a female was face down in the bathtub in black-colored water. *(El Cajon Police Department, El Cajon, California.)*

furnished room, a surprisingly large number of marks of bloodstained hands may be found on the legs of tables and chairs. A frequently occurring bloodstain is the typical one that comes from bloody hair. Bloody hair imprints are often found on the underside of tables and chairs.

Those who examine the scene of a crime should look very carefully for bloody imprints on doors (and especially keys, door handles, and knobs), telephones, hung-up clothes, draperies, curtains, and the like. If blood has spattered on a door, it is not sufficient to state on which side; it is necessary to consider the position of the door when the blood was spattered against it, and from what direction it came.

Drops of spattered blood can indicate how far the drawer of a piece of furniture was pulled out or whether the door of a closet, kitchen cupboard, or other piece of furniture was open during a struggle. An especially important clue is a footprint in blood. Usually

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Figure 16.3 (continued)

such a print is blurred and hardly suitable for identification, but it may be possible to decide whether it was made by the victim or the criminal. One should not forget to pull down any window shades to look for marks on them. The parts of the legs of tables and chairs that touch the floor should also be examined.

Pulled-out hair found in a case of death from violence is a certain indication that a struggle has occurred. When found, it should be recovered immediately because it can easily disappear or alter its position, e.g., from a draft.

Overturned and displaced furniture gives a good idea of the direction in which a struggle moved or the route by which the victim attempted to escape. Chairs, pedestals, and other light pieces of furniture fall in the direction in which the struggling persons are moving. If there is reason to suspect that a criminal has righted overturned furniture, the articles should be examined for possible fingerprints. Murderers are usually in such a state of mind after the deed that they do not consider the risk of leaving fingerprints. When a print is found on a light piece of furniture, its position should be examined carefully; a firm grip on a chair may give rise to the suspicion that the chair was used as a weapon. When heavy furniture has been displaced, the amount of force required and the way in

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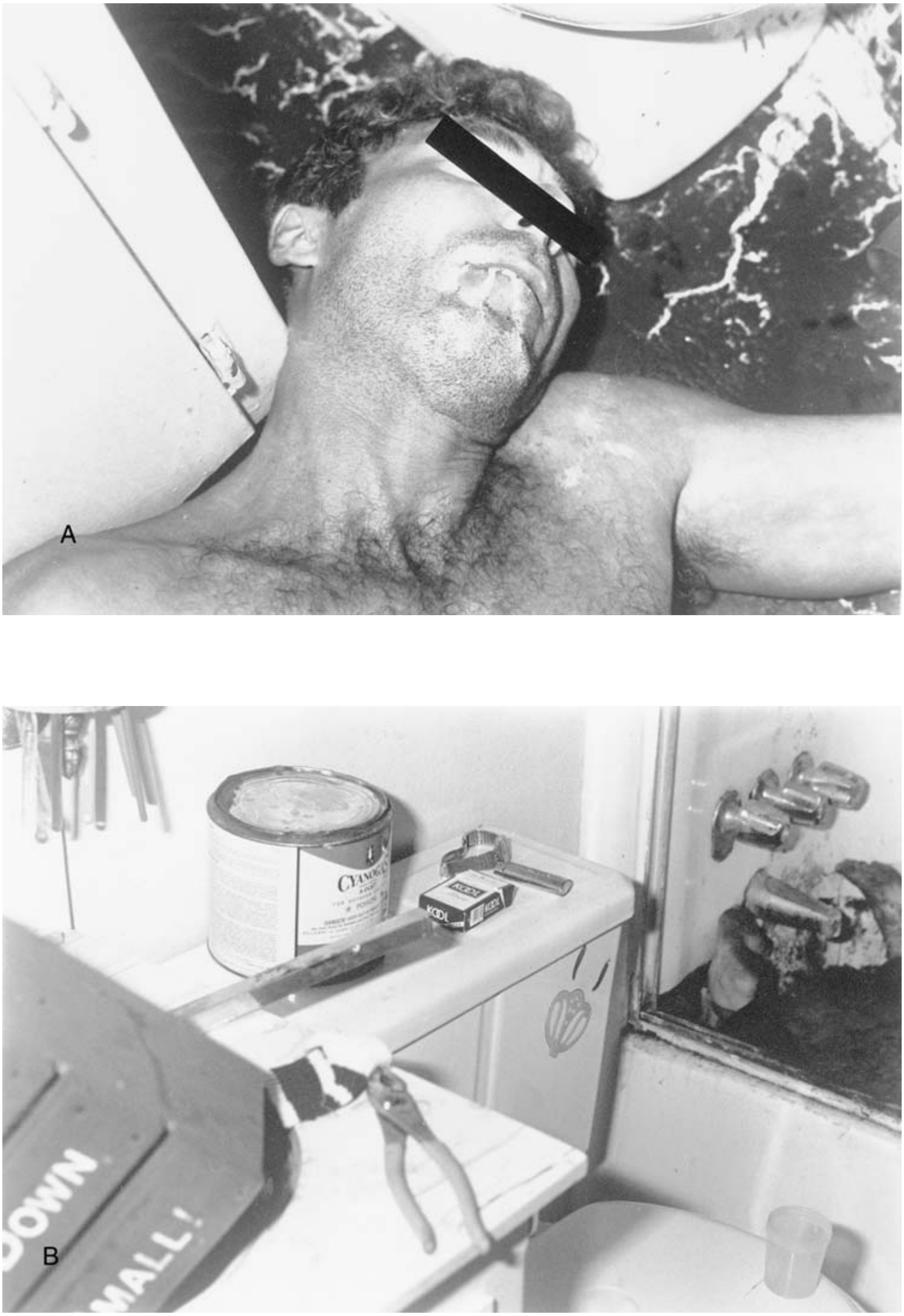

Figure 16.4 (A) There were stains on the male victim's mouth and chin and a can of Cyanogas (B) on the toilet tank. (C) The black color of the water in the tub was caused by Cyanogas. *(El Cajon Police Department, El Cajon, California.)*

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Figure 16.4 (continued)

which this force acted should be determined. Furniture placed irregularly often gives the impression that it has been displaced from its position. Marks of scraping indicate displacement and the floor generally shows clearly whether furniture has stood in the same place previously. Rumpled rugs often provide signs of a struggle, while marks of sliding on the floor sometimes form a useful guide.

A murder victim lying in a position of self-defense may kick against a wall, the floor, or furniture and the shoes then leave marks of shoe polish, dirt, and rubber scraping. Such marks should also be looked for on the undersides of the furniture.

Marks of weapons may occur, e.g., when an ax is swung and scrapes a ceiling or slips along a piece of furniture, or when the victim avoids the blow and the weapon hits the wall, floor, or furniture instead. In the case of murder with an ax or similar weapon, a frequently occurring mark is one formed on walls when the criminal swung the weapon up and back before striking. A bloodstained weapon may leave a bloodstain at a place where it was laid down or dropped. For example, if it is wiped on a handkerchief, the edge or head may leave a print in blood. Indications of weapons also include the presence of cartridges, cartridge cases, bullets, and bullet holes.

Defense injuries are a fairly certain indication that a fight has taken place. In cases of suicide and accidental death, marks are often found that at first sight appear to be marks of a struggle. Persons weary of life may have taken a number of measures at various places to shorten their life. In a state of confusion, the individual may overturn or move furniture and also leave blood and other marks that at first cause suspicion. A careful investigation of the scene, however, can give a clear picture of the true course of events.

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Figure 16.5 (A) to (D): Multiple stab wounds in the abdomen, side, and neck of female victim. *(El Cajon Police Department, El Cajon, California.)*

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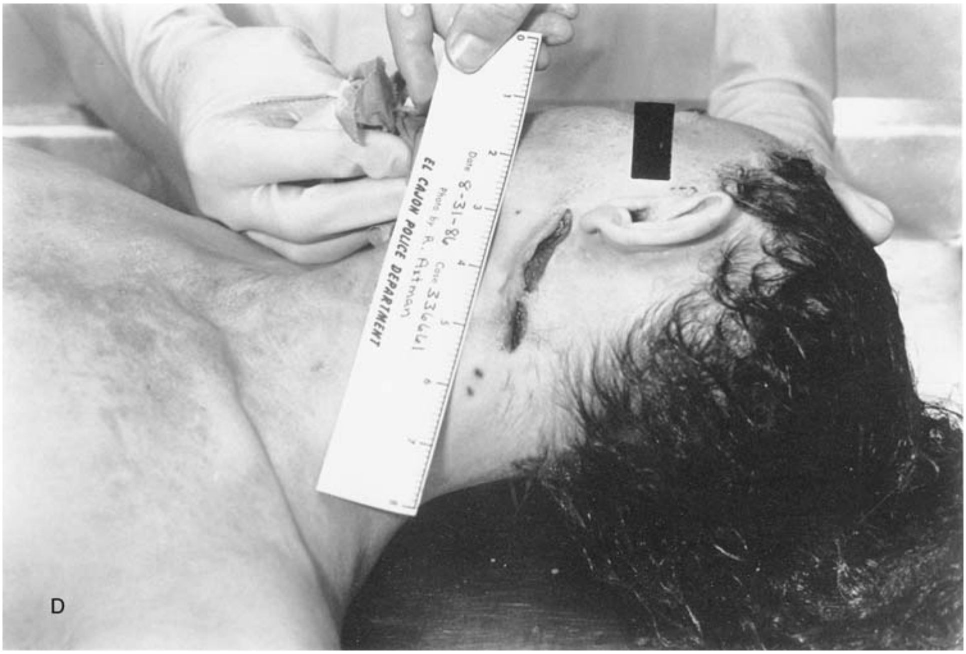
C



D

Figure 16.5 (continued)

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In cases of death by violence outdoors, signs of a struggle are in general not so distinct as those indoors. If a fight preceded the murder, the ground will be trampled. When footmarks made with shoes of different sizes and appearances are found or if the marks have the form that results from feet set down obliquely against the ground, these marks must be considered as evidence of a fight. At the scene of a suicide, especially in a case of hanging, the ground may be trampled, but as a rule the marks have the normal appearance of those of a person walking. Other signs of a struggle outdoors may be bloodstains, pulled-out tufts of hair, marks of weapons, and resistance injuries. Broken twigs, trampled leaves, torn-up moss and grass, footprints at places that a person would normally avoid, and other such indications can also be considered signs of a struggle.

Location of Weapon

In cases of violent death, the cause of death must be decided as soon as possible so that a search for the weapon, tool, instrument, or other lethal object can be conducted. The absence of a weapon or instrument at the scene indicates murder. If the weapon or instrument has been found, then the analysis of the situation must give a preliminary decision as to whether it is a case of murder or suicide. In searching for a weapon, nothing should be moved or altered at the scene of the incident, if evidence may be destroyed in the search, then the search must be postponed. If the weapon is found, it should be photographed and described in the position in which it is found. A pathologist should always be consulted when it is necessary to determine if an object can be considered a dangerous weapon.

Examination of a Dead Body at the Crime Scene

Before examining a dead body, the police officer should consider all the precautions to be taken during the course of the work. A careless move — even one so slight as undoing a button or lifting a flap of a garment — may subsequently prove to be a great mistake. An example is on record of a police officer who, in misdirected zeal, proceeded so far with the examination of a dead body that an attempt was made to determine the track of a bullet and depth it had penetrated into the body by probing the wound with a pencil. Such measures are entirely misguided.

When clothing is found on the body, it must be examined at the same time as the body, but if a pathologist is not present the examination should include only the visible parts. The clothing's position and state should be described in the report including, among other matters, how clothes are buttoned, attached, creased and wrinkled, marked by injuries and stains, and so on.

The position of the clothes, for example, how far the pants are pulled up, whether garments are twisted sideways or pulled down or even inside-out, may be of great importance. Any displacement from the normal position is measured. Buttons and other fastenings, e.g., zippers, safety pins and casings, are described. Unbuttoned or torn-off buttons are indicated, as are buttonholes. Shirts should be checked to determine if they button right to left or left to right. Sometimes, men wear women's clothes and vice versa.

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Folds in the clothes should be examined, especially on the lower parts of the body. The report should indicate whether the folds go horizontally or vertically and if they have resulted from crumpling of the garment. When a body is dragged along, horizontal creases occur that are dirty on the outside but clean in the folds. When a body is lifted or moved by a grip on the clothing, characteristic formations are produced. If the raised part of a fold is bloodstained but the inner part is free from blood, then the position of a part of the body when violence was exerted can be determined with certainty. If a garment is bloodstained and sharply delineated clean areas are on the inside of the bloodstain, then the fold formation can be reconstructed.

Damage to the clothes occurs from tearing, crushing, cutting, or penetration by edged weapons, ax blows, etc. The damage should be measured and the report should contain statements of the type, position, size, and manner of occurrence of the damage. In pertinent cases, the damage to the clothes should be compared during the autopsy with the position of corresponding wounds on the body. In this way, important information can be obtained regarding a particular body position when the injury was inflicted.

Stains may consist of blood, semen, saliva, phlegm, vomit, feces, urine, or other liquid, as well as dust, dirt, or other contamination. They are described with reference to type, location, size, and, in pertinent cases, direction of flow. If liquid stains go through clothing material it is necessary to determine from which side the liquid has penetrated.

In describing blood marks on a dead body, the terms generally used are bloodstain, blood smear, blood spatter, and stains from dropping blood. Bloodstain means marks containing a lot of blood, which occur from direct bleeding or when, for example, a garment is soaked in an accumulation of blood. Blood smear means a mark with a smaller amount of blood and can occur when a bloodstained object brushes against or touches something. A special form of blood mark is a fingerprint in blood.

Important information can be obtained from blood, saliva, phlegm, vomit, urine, or other liquid stains on a dead body if the direction of flow is observed. Especially, streams of blood can contribute to the reconstruction of events in a case of death by violence. All marks of blood flowing “in the wrong direction” are examined and photographed.

A special form of blood mark is blood froth. When a person continues to breathe after blood has penetrated the air passages, a thick froth is formed that can become so extensive that, if the face is turned upward, it comes out of the mouth and nasal passages in the form of billowing foam that can be several inches thick. Frothing can also occur on putrefied bodies when gases create foam in the decomposition fluids.

Occasionally, a case of murder occurs in which the criminal wipes or washes the blood away from the victim. Such cleaning is generally easy to detect, especially when the skin is clean around the wound. Washing or wiping the hands generally leaves a thin rim of blood on the nails near the cuticles. When the blood has coagulated, small rolls of blood and dirt are often formed and penetrate cracks and hollows of the skin. If blood has been washed from the head, this fact is often easily detected by the traces of blood that remain in ears, nostrils, and hair. Moisture around the body may also reveal washing with water.

In connection with the occurrence of blood at the scene of a crime, some attempt should always be made to estimate the amount. If blood has flowed out onto an absorbing layer, the depth of penetration should be determined. Floorboards should be lifted.

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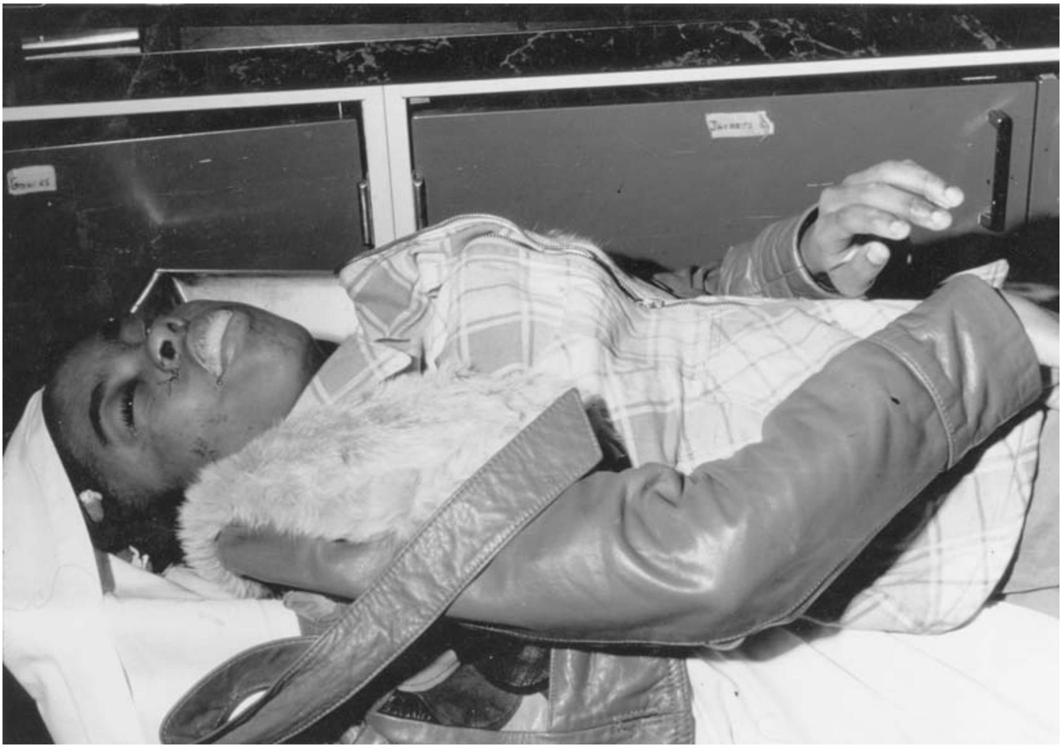

Figure 16.6 Frothy fluid at the mouth in this case probably indicates a drug overdose. *(Alabama Department of Forensic Sciences, Mobile, Alabama.)*

Murder

Case

A woman was found lying dead outdoors, with her head partly shattered by a number of ax blows, from which it could be assumed that most of the blood had been lost from the body. Under the head of the dead woman only a small amount of blood, possibly half a pint, was found. From this it appeared that the woman had not been murdered at the place where she lay. On further investigation, the lost blood was found at a place about a quarter of a mile from the body. It was found that the woman had been murdered there and that the body had then been transported to the place where it was found. If the small amount of blood at the place where the body was found had not been noticed, it is possible that that place would have been considered the scene of the crime and investigated as such, while the actual scene of the crime would never have been known. Investigation of the latter produced evidence against a local suspect who later confessed to the crime.

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In examining a dead body it is generally possible to take the necessary steps in a certain order, which is a guarantee that nothing will be forgotten or neglected. The various steps in an investigation when a pathologist is present are described next. If the pathologist does not arrive in time, the investigation is carried out in the same way, but the investigator's moves must be reconsidered so that clues that only a medical expert is capable of judging and investigating are protected as much as possible.

The first measure that should be taken without delay is to confirm the appearance of signs of certain death, of which the type and development and the time of their confirmation should be noted in the report.

The body is then photographed. Preferably, all photography should be completed before the position of the body is altered. If for some reason a change has been made after it was discovered, e.g., when relatives cover the body or the pathologist looks for signs of death, the actual position should be photographed first, and then the original position is reconstructed and photographed. The camera should be held in readiness for additional pictures during the course of the examination.

A preliminary investigation of the pockets of the dead person may precede the more detailed investigation only when it is considered absolutely necessary. This is to be avoided if possible, but it may be necessary to confirm quickly whether there are any identification documents, wallet, purse, watch, or other valuable articles in the pockets. This examination must be done so carefully that the original position of the clothes can easily be restored later. It should be noted whether the pockets are turned inside out — this may show that they have been examined earlier.

A preliminary sketch of the position of the body is made. In view of the fact that the position will have to be altered by degrees, marks are made at certain places on the floor, e.g., at the top point of the head, ears, elbows, hands, crotch, knees, heels, and points of the toes, and these points are measured on sketches. The whole of the outer contour of the body may be marked with a continuous chalk line. If the body lies on a loose base, its position should be marked in a similar manner. If, after the body has been removed, it is found that the original position needs to be reconstructed, then it can be done easily with the aid of the chalk outline.

The position of the body is next described briefly, without any details. The body's position in relation to the nearest article of furniture, object, or fixed point is measured and noted. Then the visible clothing is described, without details.

The next step is the detailed examination. Only visible details are examined and described. The original position must not be changed. It is preferable to describe the head, then the trunk, arms, and finally the legs.

The head is described and examined in relation to its position with respect to the body, whether the eyes and mouth are open, color of the skin, injuries, presence of blood, state of the hair, presence of saliva, phlegm, vomit, and foreign bodies (soil, sand, vegetable matter, hair, etc.). The direction of flow of liquids is easily determined on the skin of the face and should therefore be noted.

In examining the trunk, note should be made of its position, any bending or twisting, the position of visible clothing and condition, folds, injuries to the body and clothes, presence of blood, saliva, semen, phlegm, vomit, and foreign bodies (especially hair).

Then the arms and, finally, the legs are examined in the same way as the trunk. The hands should be given special attention. The presence of rings, jewelry, or wristwatch or marks left by these objects should be noted. Foreign objects are examined, especially

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fragments of hair or skin under the nails. The dirt from the nails should be collected. If a detailed examination of the hands cannot be made on the spot, the hands should be enclosed in clean paper bags tied securely at the wrists. When examining the legs, the distance between the knees and between the heels should be measured. Special attention should be given to the soles of the feet or shoes with respect to the presence of blood or other material in which the person may have stepped.

After examining the visible parts of the body, the police officer should attempt to visualize the course of events as deduced from observations. The officer's judgment should not be relied on solely; the opinions of others, especially the pathologist, should also be considered. From a number of opinions it is often possible to get a good reconstruction of the events.

The underside of the body and those portions covered by clothes should not be examined at the scene, unless it is done in the presence and at the request of the pathologist. Normally, the body will not be turned over or undressed until the time of the autopsy. However, after the body has been photographed and described in all pertinent detail and has been lifted onto a stretcher, the area under the body should be examined. A critical piece of evidence may have been hidden under the body, perhaps in a large pool of blood. Bullets, or fragments of bullets, sometimes penetrate a body completely but are stopped by clothing. The projectile may thus roll out of the clothing of the victim and may even be overlooked, unless great care is exercised in lifting and transporting. The relationship between the location of injuries and bloodstains on the floor should also be established.

The body should be transported in the position in which it was found, if possible. If necessary, the clothing can be fixed in its original position by means of pins. In appropriate cases, the body should be moved on a clean sheet of cotton or plastic, or on an undertaker's impregnated paper sheet. This is partly to protect the body from contamination and partly to prevent minute evidence from being lost.

An officer should accompany the body to the hospital, morgue, or other place at which the autopsy is to take place.

Detailed Examination of the Scene of the Crime

After the preliminary investigation has shown that death was caused by the intent or agency of some other person, or by suicide or accident, the detailed investigation can begin. How thoroughly this is to be done must be decided for each particular case. In suicide or accidental death, the detailed examination can be limited simply to those matters that appear to be directly related to events. If the death is caused by the intent or action of another person, everything should be investigated, even in cases where the criminal has been arrested immediately after the crime and has confessed. In such cases, the investigation should decide whether the statements of the criminal are consistent. In a first statement, a criminal often makes consciously incorrect statements about personal actions in order to create extenuating circumstances. Those who investigate the scene of a crime have an opportunity of producing such an accurate reconstruction of the actual course of events that such an attempt by the criminal cannot succeed.

When the examination of the body has been concluded, the body can generally be removed for the autopsy. Photographing the scene of the crime should have been completed before this.

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Before the body is taken away, the places at the scene where coroner personnel will need to walk should be examined for evidence that might be destroyed, including the presence of blood. Even if the body is wrapped up well, drops of blood may fall from it as a result of unforeseen circumstances. Such marks can cause much unnecessary work for the investigators later. Those who carry away the body should be warned not to step in any blood.

As a rule, the investigation can then be continued with attention to such details or places where anything of significance might be expected. Then follows a methodically planned examination of the scene of the crime as a whole, which will be the basis for the report of the investigation. It is started at a suitable point and everything is inspected in such a way and in such an order that nothing is forgotten. It may be convenient first to examine and describe the entrance, doors, and lock arrangements. Then a description of the room as a whole without going into detail follows. The length, width, height to ceiling windows, doors, floor covering, paint on walls and ceiling, color of wallpaper, lighting conditions, and other features should be described. Next, the room is described in detail and investigated in a certain order beginning from the entrance or from the place of death. Everything must be examined and described as a coherent whole. For example, if a writing desk is examined, then a description follows of the nearby parts of the floor and walls and also of the surface of the floor under the piece of furniture. As a rule, it is best for the ceiling to be described and examined last and as a whole. If for some reason a place has been examined in detail and described earlier, then a reference to it is put in the notes to facilitate writing of the final report.

In the investigation everything is noted, even if it appears to have no significance in the case. Such unessential details are sorted out when the report is written, as are similar details that appeared to be important at first but were later found to be immaterial. The notes made at the scene of a crime must not under any circumstances be thrown away but should be placed in the file and kept with the records. Experience shows that such rough notes may be of great importance at some future date if the investigator is required to prove that the examination of certain details was not omitted. It is convenient to develop and preserve finger- and palm prints at the same time as the final detailed investigation.

As far as possible, everything should be put back into its original position. When furniture is moved, it should be replaced with the greatest accuracy because the scene must be in its original state in case the suspect or witnesses are returned to the scene for questioning. Before any furniture is moved, a chalk mark should be made around the legs or other suitable parts. Objects placed on furniture can be treated similarly.

A final important step prior to sketching the scene of the crime is measurement. It is desirable to do this earlier, but this may not have been possible because of a risk that those who did the measuring might have destroyed evidence not yet discovered or produced fresh and misleading clues. One method that can be used is to have a preliminary sketch made as early as possible. Gradually, as the investigation proceeds and before each object is moved, measurements are made and recorded on the sketch. This method is somewhat inconvenient, however, because the measuring cannot be done as systematically as is desirable. Under such conditions, even experienced sketchers can easily forget important measurements.

When there has been a shooting at the scene of the crime, it is necessary to look for weapons, cartridges, cartridge cases, and bullets. If a weapon is found, it is photographed at that spot, and a chalk line is drawn around it before it is moved. Fingerprints are recorded

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before the weapon is examined. In cases of presumed suicide, it is necessary to check whether the weapon lies in a place to which it might have dropped or slid. The base on which the weapon lies should always be examined. A dropped or thrown weapon generally leaves a mark, e.g., a scratch or dent in the furniture or floor, and the absence of such marks should be considered suspicious.

When cartridge cases are found, their position should be noted in the report, on the sketch, and on the envelope into which they are then placed. Bullets and bullet holes are examined. The place from which the shot was fired can be determined quite accurately from the direction of the bullet penetration — a string is stretched along the calculated path of the bullet. The reconstruction is then photographed. A bullet that has buried itself in a wall is cut out, but great care must be used so that the tool used does not touch the bullet. In cases of suicide, the shooter may fire one or more trial shots before firing the actual suicide shot.

The following is a list of certain details that should be examined where appropriate. Because it consists partly of items of a changeable nature, they should be done immediately or as soon as possible, especially those easily forgotten or passed over even by an experienced investigator:

Stairs, passages, and entries to the scene, together with streets, passages, and yards in the immediate vicinity. Are there bloodstains or fingerprints on railings? Are objects present that the criminal has dropped or thrown away? Is there illumination? Do trash cans contain evidence? If there is an elevator, the elevator shaft should be examined.

Outer doors. Are they bolted and/or locked? Are there marks of breaking in? Does the doorbell work?

Windows. Are they bolted? What is the position of the window catch? Are there marks of breaking in or a possibility of seeing in? What is the position of curtains and blinds? Are there indications of marks outside the windows?

Mailbox. What is the date on mail or papers; are they in the right order of time?

Other papers and mail, daily milk supplies, etc. at the scene of the crime. Are there date marks? Have letters been opened or do papers give the impression of having been read? What is the number of milk bottles?

Inside doors. Are they bolted and/or locked; on which side is the key?

Hall, entrance. Are clothing and objects present that do not belong to the place and residents there, especially outer garments, headgear, scarves, gloves, galoshes, umbrellas?

Lighting. Which lamps were on when the crime was discovered? What are the electric meter readings?

Television, stereos. Have they been left on or off?

Heating conditions. Is there any fire or embers in fireplaces or any remaining heat? Do not forget to examine ash and burned residues and the setting on the thermostat.

Cooking conditions. Is the oven or stove on or is there any remaining heat? Was food or drink preparation in progress? In what condition is the food in the refrigerator?

Odors. Gas; gunpowder; strong tobacco fumes; alcohol; perfume?

Clocks and watches. Are they running and showing the right time? When did they stop? Is there a time set on the alarm clock?

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Signs of a party. How many bottles are present; are there labels on them and what are their contents (not always same as label)? Are seals or corks on or in the bottles? How many glasses or cups of different kinds are present; what is their contents and is there a residue or odor in them? Has liquor been spilled or objects overturned? Have cigarette butts and match sticks been thrown on the table or floor? How many persons was the table set for and what dishes? Are there any fingerprints?

Contents of ashtrays. Are there remains of smoked tobacco or brand marks on cigarette butts? How were they extinguished? Are there marks of lipstick, burned matches? Remember that DNA and fingerprints may be present on cigarette butts.

Drawers and compartments in writing desks, cabinets, or other furniture. Are they shut and locked? In which drawer is the key? Have drawers been pulled out or taken away or have objects been taken out of them? Are there signs of disorder such as might result from a hurried search? Are cash, bank books, and objects of value exposed in a conspicuous or easily detected place?

Wastepaper baskets, trash cans. Has any object been thrown there by the criminal? Are there torn letters?

Kitchen, bathroom, toilet. Are towels, rags, and like objects damp or do they show bloodstains? Are there bloodstains on counter, bath, sink, toilet, or buckets? Are there objects or suspicious liquids in the water-trap or toilet? Are there fingerprints on any used paper?

Damage to ceiling, walls, and furniture. Investigate how it could have occurred in connection with the crime; marks of plaster or paint soon disappear from the floor due to trampling.

Garments taken off. At what places and in what order, beginning from top, were they taken off? Are they turned right side out or inside out? Are they properly hung up or in disorder?

General disorder. Is this typical of violent happenings or a struggle; can it result from lack of cleaning up over a long period, or incidentally, for example, in carrying out ordinary household operations, etc.

Shooting. The investigating officer should be able to account for the actual number of bullets fired together with a corresponding number of cartridge cases, or give a good explanation of why they are not found or cannot be found in the correct number (consider the possibility of a cartridge case getting caught up in the clothes of the dead person and not being found before the autopsy).

Hanging and strangling. Quickly confirm whether the cord used was taken from the scene or locality.

Suicide note. Is it in the handwriting of the victim? Has the writing instrument been found? Has indented writing come through onto the paper underneath? Is there more than one note? Are there fingerprints of persons other than the deceased?

Hiding places for weapons or objects that the criminal wished to conceal quickly. Some of the places most often forgotten by the investigating police officer are locations above appliances and high furniture or between these and the wall, behind books in a bookcase, among bedclothes in a bed, behind heating elements, and on high shelves in wardrobe, pantry, and kitchen cupboards.

Compost heaps, manure heaps. These are very convenient for concealing objects without distinct signs of digging.

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It is suggested in cases of serious crime that when the investigation has been concluded, the scene of the crime be kept intact until the final report has been written and read through by the superior officer and the prosecutor, recovered evidence has been examined, and the postmortem examination has been completed. When material recovered for examination has value as evidence, it should be preserved even after the criminal has been tried. There may be a review of the case, perhaps several years later, and the evidence may then need to be produced.

Outdoor Crime Scenes

The examination of a crime scene located outdoors must be planned quickly and carried out as soon as possible. Changes in weather conditions may completely jeopardize the chances of finding evidence that is there. A number of different clues easily detected at first may disappear in a very short time, for example, by precipitation, drying, vegetation, flood conditions, etc. It is even more difficult to examine such a scene at night.

Figure 16.7 (A color version of this figure follows page 256.) Identification of decomposed remains requires techniques such as forensic odontology and forensic anthropology, as discussed in Chapter 6. This victim was murdered and dumped in Los Angeles County's high desert, where animals consumed facial tissue and hands. *(Los Angeles County Sheriff's Department.)*

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Because bloodstains on grass change color rapidly, they are difficult to detect. A brief shower may completely wash away smaller stains. Other biological evidence, such as hair, seminal fluid, urine, feces, vomit, saliva, nasal secretions, skin fragments, brain substance, and so on, is quickly changed by drying or may be washed away. During the time of year when insects are particularly plentiful, biological evidence may be destroyed by their action. The path of a person through dewy grass may be discernible to the naked eye, but after an hour or so of direct sunlight the dew is dry and the grass has recovered its original shape. It may subsequently take hours before this track can be followed. Footprints and tire marks should therefore be protected and recorded as soon as possible.

When a shooting has taken place outdoors, the direction of firing must be determined quickly. Fresh twigs and leaves that have fallen to the ground usually mark a bullet's path through foliage, bushes, or hedges. After a few hours, these traces may have taken on the appearance of the surroundings. It may thus take hours to establish the direction of firing from these clues. Evidence of a bullet striking the ground is usually found in the form of dirt or sand thrown over the surrounding vegetation. A passing shower may wash off these traces and make the location of the impact impossible to find. Cartridge cases may be trampled into the ground.

The crime scene must be effectively roped off and the investigating officer must follow a definite plan of action. Experience has shown that officers who carelessly and aimlessly wander around the area put some of the evidence found at outdoor crime scenes there.

In cases of suspicious death, the officers can anticipate that the person, or persons, who discovered the body did not enter the scene with caution — which is to be expected. One of the first duties of the crime scene investigator is therefore to find out where those persons walked. The record of many cases has shown that clues created by these citizens have caused a tremendous amount of unnecessary work that could have been avoided if the person had been properly interviewed.

In making up a plan of action, the officers should decide on a path to be used in going to and from the body. Because this path will be used frequently, it may be marked with stakes. The examination of the body then follows according to the outline given earlier in this chapter. Before too much attention is given to the body, the ground around it should be carefully examined. A second chance will hardly be available after a number of persons have looked at the body and trampled the area. The area surrounding the central scene should then be examined.

The investigators must try to remember their own tracks so that they can distinguish them from others that may be discovered. On snow-covered ground this is easily accomplished by investigators dragging their feet so that their own tracks become distinctive.

Insofar as possible, examining outdoor crime scenes at night should be avoided. This rule should be followed even when suitable illumination is available. Most clues at outdoor scenes consist of minor changes in the ground cover, such as matted grass, torn moss, broken twigs, indistinct footprints, and the like. Such tracks may be visible from several yards away in daylight but are almost impossible to detect at night even with powerful illumination. If a scene is viewed at night and an estimate made of the topography, it might be found in daylight that the picture is quite different. Because it is difficult to survey the scene and correctly interpret even gross evidence, it follows that it is even more difficult to find evidence as small as bloodstains, fragments of cloth, and fibers. Such evidence may be overlooked or destroyed if a thorough examination is attempted in darkness.

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Figure 16.8 (A color version of this figure follows page 256.) Skeletal remains found in remote areas offer a special challenge to the investigator. In this case, absent anything more than part of the pelvis and long bones, a forensic anthropologist may only be able to provide an estimate of height, stature, and gender of the victim. Missing person reports and debris scattered in the vicinity of the remains may offer additional information. *(Los Angeles County Sheriff's Department.)*

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Prevailing weather conditions or expected weather changes play an important role in deciding whether to postpone the examination until daylight. If there is a chance of snow, the examination must be started even if important evidence may be destroyed. Depending on the type of crime involved, other weather conditions may also have a certain influence. If snow falls before the examination is completed, some evidence may be covered and not retrieved until the snow has melted.

Whenever the examination must be done immediately, it is better to refrain from recovering the evidence and instead cover it with tarpaulins, boxes, or similar protective devices and then wait for daylight for the completion of the examination.

Before the arrival of daylight, certain precautions should be taken. Some flash exposures should be taken of the body. The body should then be covered with a clean sheet over which is laid a tarpaulin in order to keep out dust, leaves, and other debris. If the body is suspended, the noose may break, and it is advisable to secure the body with a rope tied loosely around the chest. If the body is on the shoreline, it should be lifted far enough onto the beach so that swells will not make changes on the body.

In taking the photographs and the precautionary measures, the officers should not walk around aimlessly. As described earlier, a path should be selected and marked with stakes. The investigator should, of course, make note of changes that may take place on the body, such as signs of death, moisture on the clothing and under the body, and so on.

Discovering a Body Hidden at Another Location

When a homicide victim has been moved from the actual crime scene and hidden at another location, conditions are somewhat different. Although the examination of such places is generally carried out in the same way as at crime scenes, a reliable reconstruction of the crime is usually not possible. Such locations normally do not yield as much evidence of the criminal as the place of attack.

The question often arises as to how long the body has been lying at the place where it was found. The vegetation and other surrounding conditions the body may give some indications. The path over which the body was transported should be established at the outset. This detail should be attended to immediately, especially when there is risk of precipitation. If the criminal's footprints are not clear enough, the path should be estimated as that most easily traversed if someone were carrying a body. Even when there are no footprints, other signs may be present, such as trampled grass, stains of dripping blood, marks from dragging, broken twigs, etc. If the criminal left the scene by another route, this path should also be examined in due time.

The body should be examined as described earlier in this chapter in the section "Examination of a Dead Body at the Crime Scene." Dust, dirt, and other traces on the skin and clothing that might point to the scene of the crime should be recovered. A preliminary evaluation of such traces may suggest leads for the search for the actual scene. In removing the dead body from the place where it was found, it should be placed in a new body bag, clean plastic sheet or bed sheet that is then wrapped around the body. Blankets and tarpaulins should not be used because one can never be sure that they are absolutely clean. Because it is almost impossible to examine and recover traces on the body properly, it should be transported intact to the place for the autopsy where the detailed examination can take place.

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After the body has been removed, the area underneath it should be examined. The amount of blood and body fluids should be estimated. It should also be determined how deeply into the ground such fluids have penetrated. If the murder weapon is expected to be found in the area, a search for it should be started. If branches, straw, and the like were used to cover the body, they should be examined for the possibility that the criminal may have dropped something while engaged in this activity.

Investigation of a Greatly Altered Body or Skeleton

Often difficulties arise in the identification of a dead body that has undergone such a great amount of alteration that only the skeletal parts and portions of tissues and organs are left, or where the usual methods for the identification of a body can be employed only to a limited extent. Important information can be obtained from a skeleton found wholly or partly preserved after a very long time or after burning or other destruction of the body, and also from any remains of tissues or organs or of clothing or other objects that belonged to the dead person or can in some other way be connected with the discovery of the remains of the body.

Such bodies or their remains are most frequently discovered outdoors; occasionally, they are found indoors in a cellar, attic, heating furnace, or other places. The remains may be those of a person who was murdered, run over by a vehicle, or committed suicide, was lost and became the victim of exhaustion or exposure, or was suddenly overcome by sickness and death.

From what has been said, it follows that the nature of the place where the discovery is made can vary considerably. Remains may be found under the ground or under a floor or the like; they may be lying in the open, covered with brushwood, moss, sacks, and so forth, or overgrown by vegetation. If the body was originally in the open outdoors then the remains (both bones and clothing) are often dispersed over a large area owing to animals having dragged them away. It is not uncommon for remains and objects with some connection with them to be found several hundred yards away from the main site. This also applies to parts of a dismembered or burned body that have been buried or left on the ground because different parts may have been concealed or buried at different places, often far apart.

If there is reason to suspect that the individual from whom the remains are derived was killed at or near the place of discovery, it is possible that the murder weapon or objects thrown away by the deceased or by the murderer (shoes, fragments of clothes, ornaments, etc.) may be found within a comparatively small area around the site. In the case of an individual who was lost, in the course of wandering a backpack may have been thrown off and making a bed of clothing, etc. attempted; this forms another reason that the investigation should not be restricted to the actual site of the discovery. Remains and fragments of clothing, and especially objects in pockets, often play an important part in the identification of the dead person; the possibility of determination of gender from the clothes is especially important when the remains of the body are only fragmentary or inconclusive with regard to gender. Under certain conditions clothing may be in a better state of preservation than the remains of the body.

Foreign objects connected with the body or with transport of the body to the site (bags, sacks, cords, etc.), which possibly form the sole proof of a crime and may even

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indicate how to trace the criminal, may also be found near the remains. A number of cases have occurred in which a correctly performed and accurate investigation of the place of discovery, combined with careful technical and pathological investigation of the remains of the body and other related objects, has led to the identification of the body. In order for the best result to be obtained, the investigating officer needs a good knowledge of the proper method of investigation and preservation of the remains and objects, and of the factors that affect distribution of the objects within a larger area.

The officer also needs to know the special methods used for further investigation of the discovery and how these methods can assist in determination of gender and age of the deceased and of the time elapsed since the objects were first placed there. This knowledge is absolutely essential if the police officer is to pay the necessary attention to the possibly small and apparently insignificant objects that are especially significant in these respects. The precise determination of the characteristics necessary for establishing age, gender, body structure, and so forth must be left to the anthropologist at the museum or university. Likewise, the investigator must use the services of entomologists for the life cycles of insects, of botanists for growth rates of roots, grasses, and other plants, of meteorologists for weather conditions that might suggest the time of repose of the body, as well as any other experts whose special knowledge will assist the investigation.

The Scene of Discovery

The task of investigating the scene of discovery includes searching for and recovering the remains of the body and all the objects in the area that may be of value for identification. (The methods of identifying human remains are discussed in detail in Chapter 6.) As in all cases in which a body is found under such circumstances that a crime is suspected, the police officer should contact the pathologist so that right from the start the latter has an opportunity to become familiar with the case. For the purpose of identifying the body, the expertise of a dentist may be needed. The procedure for the investigation is, of course, not always the same, but depends on whether the discovery was made indoors or outdoors.

Outdoors

A discovery outdoors may be one of three different types according to whether the remains are found buried, lying exposed on the ground, or in water.

Remains that have been buried usually come to light in digging or other similar operations and are generally purely historical finds from old burial sites and the like. The police officer called to such a scene should first photograph it in the state in which it was found, and then expose the body with great care. During this work, preferably done with assistants and in the presence of a pathologist, detailed photographs should be taken as necessary in order to show the position of the body, noteworthy details or conditions, etc.

In exposing the body, special attention should be given to the occurrence of any filling material above it that differs from the surrounding earth, to any objects used as covering near it, and to any foreign material or bodies in the ground or near the body. It has happened that quicklime has been placed on bodies to accelerate the decomposition and make the identification difficult. If anything of this kind is suspected, a sample of the earth should be taken so that it can be examined. Attention should also be given to the properties

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of the earth (type of soil, dampness, etc.) because this is very important in deciding the length of time the body has been buried.

The color of bones can vary from light grayish-white to dark brownish-black, depending on the age of the find, kind, and properties of the soil, whether the parts are or were enclosed or covered in some way, or the measures that may have been taken with the body before burial, e.g., more or less complete burning. It is often difficult to distinguish between small bones and stones, twigs, or other objects in the earth; therefore, the search should be carried out with great care and all remains, even if very small, should be kept. Certain very small bones and also the teeth are very important for determining the gender and age of the deceased. If the skeleton is much disintegrated, the earth should be sifted through a small mesh sieve. It is also important that any remains of hair be sought and kept.

Of great importance for investigation and identification are all remains of clothing and other objects that may be connected with the find, e.g., contents of pockets, buttons, ornaments, rings, coins, etc., and objects that may be connected directly with the crime or transport to the scene of the crime, such as ropes, cords, sacks, bullets, or objects pushed into the mouth of the victim. Such loose objects are looked for — if necessary by sifting the earth — and kept with great care because the risk of breaking into pieces may be great. Objects on or attached to the remains are not moved from their position before the discovery has been fully investigated. The position of loose objects in relation to the remains of the body should be accurately marked and sketched or preferably photographed.

In taking possession of bones and especially of remains of clothing and the like, attention should be given to their association with any vegetation. Roots of trees or shrubs that have grown through them form a valuable aid in determining the length of time the object has been there. A determination of the age of a root of a tree that has grown through clothing gives a minimum value for the time the object has lain in the ground; this can be used as a starting point for further investigations and calculations. As far as possible such roots should be cut off and allowed to remain with the object; otherwise, they must be kept and labeled with the necessary information on their origin.

Even at the scene of the discovery attention should be given to the occurrence of insect larvae and pupae or remains of them on the body. They are placed in a test tube for examination by an expert. For example, remains of fly larvae found on a buried body indicate that it was above ground for a certain period of time before being buried; the stage of development of the insect, larva, or pupa can give further valuable information.

If only a part of a body is found, then dismemberment may have been carried out before burial. In such a case a large area of the surroundings must be investigated carefully, with attention directed especially to all changes in the surface of the ground that give the impression of having been produced by human agency. If the find is of very old date, it can be assumed that any signs of disturbance of the ground will have disappeared and the investigation becomes very difficult. The character of the ground, the possibility of burial at different places, etc. must then be used to guide the search. In some cases, police dogs can be used with advantage. A sketch should be made of the terrain, giving the place where each object was found, and photographs taken. In photographing, each site is marked with a number or letter visible on the photograph and these are also shown on the sketches. The objects found at the different sites are placed in cartons or boxes marked with the number or letter given to the discovery location in the photographs and sketches.

A search for evidence in the vicinity of such a discovery, e.g., evidence of the criminal, vehicle tracks, or the like, usually has a low pay-off because of the long time that has

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generally elapsed since the crime was committed. However, marks on stems of trees or the like from vehicles, a bullet, and so on can be found after a comparatively long time, so a routine search should be made if the find is thought not to be too old. It should be remembered that trees and bushes might have grown considerably since the crime.

The discovery of a dead body found lying exposed on the ground is usually made in a forest, on a mountain slope, or at other lonely places.

If dismembered body parts are discovered, the investigation of the scene must be extended to cover a large area. In this case it is quite normal for the parts of the body to be scattered over a number of places at some distance from one another. The same applies, however, to bodies that have not been dismembered because various animals and birds can drag the parts for a distance of up to several hundred yards from the original site.

Careful attention must be given to those cases that appear to be hiking, mountain climbing, or camping accidents. These may be the result of an attempt to cover up criminal assault or robbery. Lone hikers or naturalists can be easy prey for criminal attacks. Special attention must be paid to the absence of valuables, minor bruises from subduing blows, and evidence of soil or vegetation not found in the immediate vicinity. The investigation of a discovery of this kind is made in exactly the same way as for a body that has been buried. Special attention should be given to the relation of the vegetation to the find because this may be decisive in determining the length of time the body has lain there. Under the remains at the original site, smothered plants may be found or possibly no vegetation at all. Plants may have started to grow over the remains. If the body has lain there for several years, grass, brambles, undergrowth, moss, or other vegetation may have completely concealed part of the remains. The remains may have gradually become covered with a layer of soil or leaf mold from falling leaves and dead plants. Roots of trees and bushes may grow through parts of the find and especially remnants of clothing. The vegetative conditions should be described carefully, stating the type of vegetation and supplemented with photographs on which the different remains are marked in the manner described earlier. Any tree or other roots that have grown through the remains are kept for a determination of their age. If there is no risk of the roots falling out of the remains when they are collected, then the roots should be removed with them. A sketch should be made as described previously.

The place of discovery should be cleared and any remains and objects found kept. If necessary, the earth is sifted and may be preserved for further examination or analysis. The character of the ground, i.e., type of soil, dampness, etc., is described. If there are signs of foreign matter such as lime, samples are taken. When exposing the body, attention should be given to any indications of its having been covered with stones, brushwood, sacks, and the like. When necessary, detailed photographs are taken.

If remains of a body are found in water, it is generally impossible to investigate the place of discovery accurately, unless it is merely a small pool that can be drained. If this is not possible, the investigation must be limited to dragging the body of water and examining the shores. It must be remembered that currents, ice, floating timber, and other items may have carried parts of the body to places a long way from the place of discovery. Also, the find may be a body part that has been carried to the place of discovery in the same manner, possibly from a considerable distance.

If the discovery has been made in a harbor or river in which there are steamers and motorboats, propellers may have caused some of the injuries on the body. A propeller can cut off a leg or arm in such a way that it appears as if the body has been dismembered

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intentionally. Injuries to tissues and organs produced in this way often show clean cuts, as from an edged tool.

Indoors

It is very rare for remains of a body found indoors to undergo as extensive degree of change from decay or other causes as in the preceding cases. There have been cases where a body has been buried in a cellar or cut up and burned in the furnace of the heating system, or when remains of a dismembered and/or burned body have been placed in a suitcase in an attic or garage. The procedure in such a case is the same as that described above.

If a body has been buried or if remains have been found in a suitcase, sack, or the like, then all objects that have been used to conceal the body or for wrapping are of special interest. With such discoveries, the floor, walls, and ceiling of the place should be examined for bloodstains and objects should be looked for that might be supposed to have been used in connection with the crime, the burial, and so on.

For example, if a heating furnace has been used to burn a body, it should be examined very carefully. A skeleton is not destroyed by fire; even in modern cremations the remains never consist of ashes but of cracked and distorted bones. After a cremation, the volume of the bones of an adult amounts to 2 to 3.5 liters (3.5 to 6 pints). In a freshly burnt state the bones have a white to yellowish or grayish- white shade, which quickly changes to brown or brownish black in the ground. At a certain state of burning the bones are soft and may assume peculiar twisted forms that depend to some extent on the underlayer.

The contents of the firebox and of the ash space should be sifted; every fragment of bone must be kept. Certain very small bones have been found to be very resistant to fire and may therefore be valuable for determining the age and gender of the deceased. Teeth are especially valuable. The crowns of teeth generally break up and split under the action of heat, but the roots often remain whole. On the other hand, teeth that have not erupted (e.g., with children) rarely break up and do not change in form or shrink to any appreciable extent; after burning, they have a whitish color and a chalky consistency.

In searching for and taking possession of burnt skeletal remains, great care should be observed owing to their fragile nature. If remains that are especially brittle or liable to fall to pieces are found, they should be packed separately in test tubes, glass jars, or cartons according to size, with cotton, tissue paper, or the like as underlayer and filling for the container.

Packing and Transporting

Packing the remains of a body with any associated objects to be moved or sent to an expert should be done so as to eliminate any danger of destruction or falling apart of associated objects as the result of shaking or other movement. A skeleton with the long bones still hanging together, with or without remains of soft tissues or organs, should be packed in such a way that it will remain in that state during transport. Styrofoam, rags, tissue paper, or similar materials can be used as filling in the container and for the support of parts so that they do not rest on the bottom. Well-burnt remains should be transported in the custody of a police officer who keeps the package under control at all times and ensures that it is not exposed to shocks or jarring. Suitable packing materials are thin soft paper,

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soft and flexible cloth, tissue paper, cotton, and the like packed in the container so that the object has a soft support and is also supported in a definite position.

Determining the Number of Individuals

This question arises only when the discovery is composed of a collection of bones that are not connected or placed in a way in which it is possible to decide whether the remains are of one or more individuals. An investigation with this objective is based on the fact that certain parts of the skeleton occur singly or in pairs in the human body. Especially significant in this respect are the tooth processes of the second neck vertebra and the wedge bone of the inner ear. The body has one of the former, with a characteristic form, and two of the latter, which have an obliquely directed opening for the auditory nerve. Both of these parts of the skeleton are resistant to fire. They are small so great care (sifting) is required in searching for them.

Examining Remains of Clothing and Other Objects

The investigation of any remains of clothing and other objects has as its objective the determination of the original appearance of the garments, kind of cloth, color, and so on, and the detection of any manufacturer's or laundry marks. Shoes are examined for maker's marks, size, repairs, and other identifying marks. Any object found in the clothes or at the scene is investigated, keeping in mind that it may be characteristic of a certain trade or in some other way give information about the deceased or conditions in connection with the death (murder weapon, suicide weapon, objects used in transporting the body to the place, objects thrown away or forgotten by the criminal, etc.). In these investigations special attention should be given to everything that might assist in determining the length of time the remains have been there, e.g., alterations resulting from weather conditions, penetration of roots and other parts of plants into clothing, etc.

Everything that arises from this investigation is combined to form, if possible, a description of the deceased and an explanation of the cause of death, time of death, and so on; this information can subsequently be used for identifying the body as some person reported as missing, tracing the criminal, checking the statements of a suspect, and other such objectives.

The examination of any remains of clothing or other objects that may be found and can be connected with the discovery of remains of a body is a matter for the police officer, who can call in the assistance of experts if necessary. The pathologist should always be given the opportunity to be present and should be informed of the results of the examinations because these, like the investigation of the scene of discovery, are closely connected with the pathological investigation. Before the examination is commenced all objects should be laid out to dry on a table because this facilitates the work considerably.

Clothing

Roots or other parts of plants that have penetrated portions of clothing should be kept and provided with a label showing type of garment and vegetation; afterwards the material is given to a botanist for determination of age. From tree and shrub roots that have

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penetrated the remains it is possible to determine the minimum period of time that the object has lain at the site. In the case of *unburied* remains this estimate must be increased by 1 or 2 years because the material must first "merge" into the soil before it can be penetrated by roots.

The type of cloth, color, type of garment, and the question of whether it is ready-made or tailor-made are determined, possibly with the assistance of an expert. An expert should preferably also be called in to decide the length of time the material has been lying there from any changes in the garments resulting from climatic effects. Manufacturer's and laundry marks are looked for, using an ultraviolet lamp in the latter case. Buttons and the manner in which they are sewn on (by machine or hand) may be significant, as are any repairs in the garments. The remains of clothes are examined also for damage caused by edged tools, firearms, vehicles, and similar objects that may possibly correspond to marks and injuries on the body. The assistance of the pathologist is required for this. The nature of the damage can often be determined with certainty. Damage caused by animals may also occur on clothing, but this can generally be distinguished from other damage. The remains of underclothing and stockings or socks are also examined for color, textile material, manufacturer's marks, other marks, repairs, etc.

Boots and Shoes

The original color of boots and shoes may be difficult to determine because of changes to the leather by the action of earth, dampness, etc. The name of the maker, which is sometimes embossed, may be inside or at the back of the heel, or at other points on the inside; stamped marks may sometimes be a guide for identification. Any rubber soles or heels, their make, size, and types are also significant. The size of shoes can be determined from the length. Sometimes, a distinct impression of the sole of the foot and the toes can be observed on the inner sole of a shoe and this may be of value for comparison with shoes that may possibly be found in the house of a missing person. Shoe repairs may also help in identification.

Other Objects

Of great importance for identification are all objects found in the pockets of clothing or at the scene of the discovery that may be suspected of having belonged to the deceased. These objects are examined carefully, looking for name, initials, trademarks, and other markings. The description of a missing person may mention such objects or possibly relatives may be able to identify them as belonging to the deceased. It may also be important to determine the application of a particular object, which may be characteristic of a particular trade. A particular collection of objects may be typical of a hiker or a person interested in sports, fish, or game, for example.

Estimating the Time of Death

In cases of murder, suicide, or suspicious death, the determination of the time of death is very important. The most reliable estimate of the time of death comes from a variety of sources: postmortem changes such as body temperature, rigor mortis, lividity, and decomposition, and information developed during the investigation such as the last time the

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victim was seen alive. The correct estimate of the time of death is important when interviewing suspects in a homicide investigation. Such information can serve to eliminate a suspect who was elsewhere at the time of death or establish opportunity, i.e., the suspect could have been with the victim at the time of death. The investigator should realize that the estimate of the time of death is only an estimate. In some cases, a more precise determination can be made if the death occurred at or near the time of another event that was known.

Postmortem Signs of Death

After death a number of postmortem changes occur that are useful in determining, within limits, the approximate time of death. The various methods available are useful to make estimates, that is, ranges of times. The precise moment of death can be determined only in rare instances, such as when a bullet stops a clock. The amount of time between the death and discovery of the body also has a bearing on the time-of-death estimate. Generally, the shorter the time interval between death and the discovery of the body, the better is the estimate of the time of death.

Changes in the Eyes

After death, changes become noticeable in the eyes. The cornea becomes dull and a film may appear over the eye. This may appear within several minutes to a few hours depending on whether the eyelid is open or closed, temperature, humidity, and air current. Because of these factors, clouding of the cornea is not considered a reliable indicator of the time of death.

Temperature of the Body

Cooling of the body is another sign of death. The rate of cooling depends on several factors, including body temperature at the time of death, temperature of the environment, body covering and clothing, and relationship of the surface area to body weight. The body temperature will continue to fall or rise until it reaches ambient temperature, which usually occurs in about 18 to 20 hours.

Core body temperature is generally considered one of the more reliable indicators of the time of death up to approximately 18 hours. The usual way to determine core body temperature is to insert a thermometer into the liver. A comparison between that temperature and ambient temperature is used to determine the approximate time of death.

Rigidity of the Body

Immediately after death, the body becomes flaccid. Biochemical changes in body muscles produce stiffening, known as rigor mortis, which usually appears within 2 to 6 hours after death. Rigor mortis is most notable first in the small muscles such as the jaw fingers and is complete within 6 to 12 hours. The rigidity remains for 2 to 3 days and disappears gradually.

An examination of the body for rigor mortis can help indicate the time of death. If the rigidity is broken, it will generally not reappear unless the body is in the very early stages of rigor mortis. The victim's muscular development will affect the intensity of the rigidity. The very young and very old will likely develop less rigidity than adults with well-developed musculature.

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Lividity

After blood circulation stops, blood settles to the lowest portions of the body because of gravity. This is noted by the appearance of blue or reddish-violet marks on the skin (in cases of poisoning by carbon monoxide, cyanide or cold, the marks are "cherry red" and with potassium chlorate poisoning, light brown). The first indications of lividity occur in approximately 1 hour, with full development after 3 to 4 hours. Lividity can sometimes be confused with bruising or black-and-blue marks. The pathologist can differentiate between the two during the autopsy (Figure 16.9).

Under certain conditions lividity can move or change if the body is moved or the position of the body is changed. Postmortem lividity does not form on parts of the body exposed to pressure, e.g., parts that lie against the floor. If the position of the body or the position of articles of clothing pressing on the body is changed within 3 to 4 hours, the original lividity discoloration may partially disappear and a new pattern form. After this time, at least some of the original discoloration will remain. Even 9 to 12 hours after death, and sometimes later, new but successively weaker patterns are produced when the position of the body is changed, although the discoloration that was first formed is usually fixed by this time and does not change. If there was a large blood loss, livid stains will be weak. As a rule, fresh livid stains are not produced by a change in position more than 12 hours after death. Lividity discoloration may provide a limited indication of the time of death but can demonstrate a change of position or movement of the body several hours after death.

Decomposition of the Body

The most certain sign of death, one that cannot be misinterpreted by anyone, is the beginning of putrefaction. Decomposition, or putrefaction, is a combination of two processes: autolysis and bacterial action. Autolysis, the softening and liquefaction of tissue, occurs by means of chemical breakdown of the body. Bacterial action results in the conversion of soft tissues in the body to liquids and gases.

Putrefaction begins immediately upon death and generally first becomes noticeable within 24 hours by a discoloration of the skin in the lower abdomen and groin. The discoloration has been described as greenish-red or blue-green and is pronounced within 36 hours. Bacterial action produces gases causing the body to swell up, while an unpleasant odor becomes quite noticeable. The swelling is particularly noticeable in the penis, scrotum, breasts, and other areas of loose skin attachment.

Blisters filled with watery fluid and gas appears on the skin, which gradually darkens in color. Material from tissue breakdown (purge) may exude through the mouth, nose, and anus. Within 3 days, the entire body shows signs of decomposition. The environment affects the rate of decomposition of the body. Colder temperatures tend to impede putrefaction while warmer temperatures increase it.

Similarly, if the body is placed in water containing a large amount of bacteria, such as that from sewage effluent, decomposition is accelerated. A body in water generally decomposes more slowly because of colder temperatures and lack of oxygen. Because the body has a greater specific gravity than water, it sinks initially. Prolonged submersion in water causes a wrinkling effect around the skin of the hands and feet. The body orients itself in a head-down position that sometimes results in scraping of the forehead when it comes

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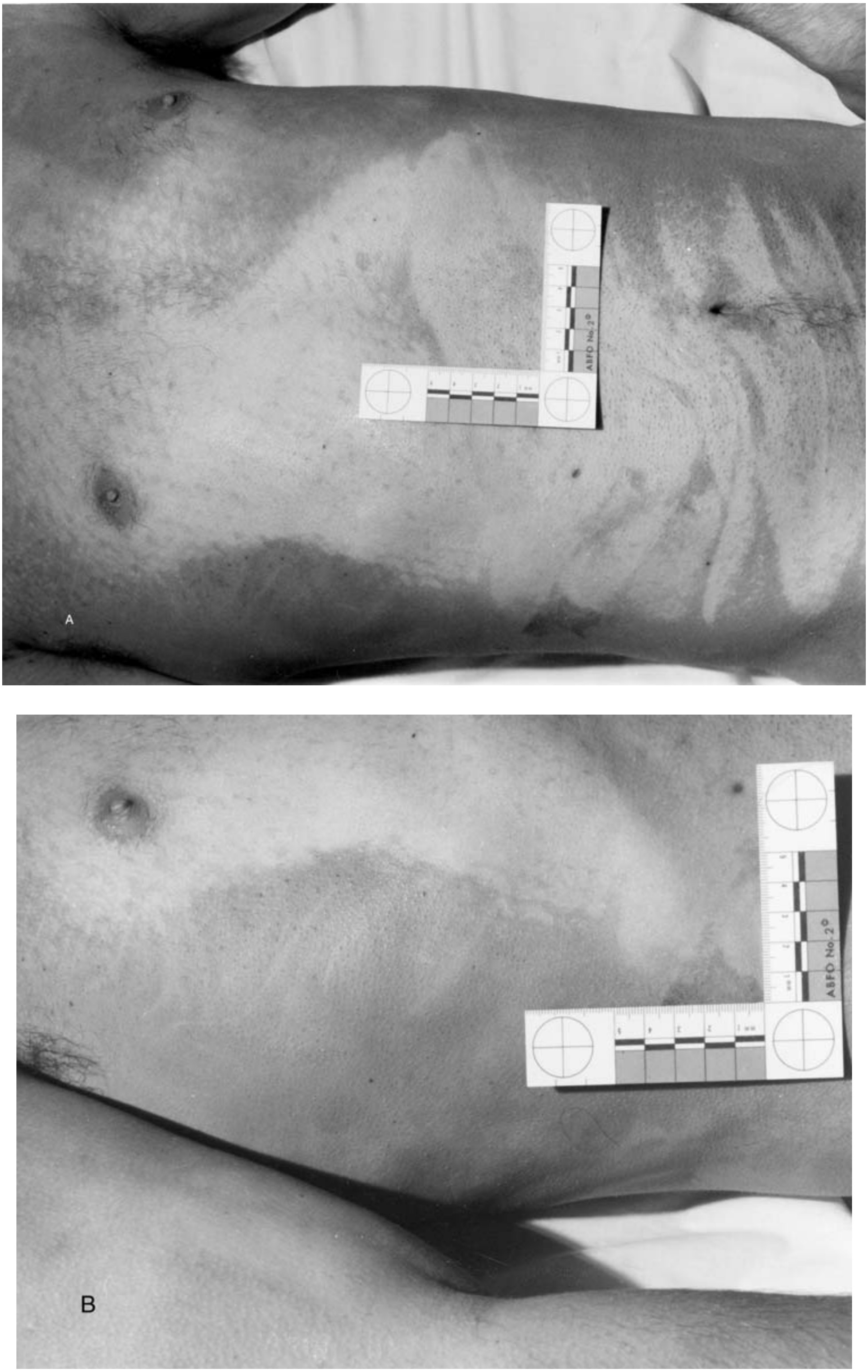

Figure 16.9 (A) and (B): Examples of postmortem lividity showing that the body was lying face down at the time of death. *(Los Angeles County Department of Coroner.)*

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into contact with the rough sea floor. After a period of 3 to 4 days in warmer water and about a week in cold, the body will surface owing to the formation of gas. Sometimes the skin and tissues burst and the body sinks again to the bottom. The process may repeat itself and the body floats to the surface again (Figure 16.10).

When a body is buried in a shallow grave with loose earth, it is destroyed fairly quickly; in 1 to 3 years all the soft tissue will disappear. The skeleton remains much longer. These time figures will vary greatly according to the type of soil, amount of water, drainage, and other such factors. In peat bogs, for example, the body will remain relatively well preserved for many years. Bodies buried in clay soil decompose at a slower rate than in other soils. In certain cases, bodies are relatively well preserved through mummification or the formation of adipocere, a wax-like substance caused by hydrolysis of body fat.

In very dry conditions, putrefaction is retarded and mummification may begin. It can become complete in warm, dry air or when a body is buried in dry, porous earth. Formation of adipocere occurs in bodies located in damp environments such as a swamp, wet soil, or even water. Adipocere is characterized by reasonably well-preserved external contours of the body; its formation is noticeable in about 6 to 8 weeks, with complete formation in 18 months to 2 years. When a body lies in a cellar or other damp place it may become completely covered with mold, leaving black marks on the body. Buried embalmed bodies may also have mold present.

Action of Insects and Other Animals on a Dead Body

When a dead body lies above ground, it is generally destroyed quickly by the action of insects and their larvae. Different kinds of insects lay their eggs in the body and these rapidly develop into larvae (maggots) that, when weather conditions are favorable, can appear in such numbers that the dead body positively "teems with life." The body of an adult can be completely destroyed in less than 2 months, with only the skeleton remaining, that of a child in less than a month. The insects that appear on a body, to feed on it or to lay their eggs in it, always come in a certain definite order, depending on the state of decomposition of the body. This question has attained great importance in medico–legal practice because, by examining the insects found on a body at a particular time, it is possible to obtain a good idea of how long it has lain at a particular place.

As a rule, the first insects that attack the body are flies. Even before death actually occurs the flies may begin to lay their eggs in the body, usually in the mucous membranes — e.g., in the eyes, nose, and mouth — but also in wounds and bloody parts of the body. The eggs are white and about 1/16 inch long, and are laid in clumps. On a body lying indoors they come especially from common houseflies (*Musca domestica*). This may be a significant point in the investigation because if eggs, larvae, or pupae of houseflies are found in a body lying outdoors or buried, it must be concluded that it has previously lain indoors. On bodies lying outdoors chiefly common bluebottles (*Calliphora erythrocephala*), greenbottles (*Lucilia caesar*), and sheep maggot flies (*Lucilia sericata*) lay their eggs. Flies can also lay their eggs in bodies buried in shallow graves. After only 1 to 2 days, the larvae of the fly come out of the eggs and immediately commence their work of destruction, changing into pupae after 10 to 14 days; after a further 12 to 14 days, the flies come out, to multiply again in their turn after a couple of weeks.

Among the beetles that live or multiply on a body, burying beetles and other kinds of carrion beetles appear on a dead body. Carrion beetles, as their name implies, are an

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Figure 16.10 (A color version of this figure follows page 256.) This adult male was missing for 2 weeks and was eventually recovered on an ocean beach after drowning. The condition of the facial tissue obviously prevents visual identification as a reliable means of identity determination. Dental records (written and x-rays) were obtained by law enforcement and used to compare with dental findings obtained at autopsy. *(C. M. Bowers, DDS, JD, Ventura, California.)*

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important part of a vast host of scavengers responsible for recycling decaying materials. When a body is buried immediately after death, insects are not able to lay their eggs. Certain types of boring worms accelerate the decomposition process into the body. Some fly species can live and multiply for long time periods in a buried body.

When larvae, pupae, or insect eggs are found on a body or in clothing, it is possible to estimate the shortest time during which it has been at the scene. This applies also to fully developed insects that, in their natural course, must have gone through all the stages of development in the body. A forensic entomologist should perform these examinations.[1]

If insects are to be sent for expert examination to an entomologist, they are first killed by placing them in a killing jar that contains a few cotton balls soaked in fresh ethyl acetate. After immobilization they are then preserved in 75% ethyl alcohol. Insect eggs, larvae, and pupae are killed and preserved by placing in 70 to 80% alcohol.

Animals often attack unburied bodies. Rats attack the projecting parts of bodies, e.g., nose, ears, and fingers. When they attack the hands, the injuries may produce the impression of being defense injuries. When such injuries are discovered, the pathologist should examine them immediately because they dry comparatively quickly, making it difficult to decide on their origin. Other animals may also produce injuries to a body, and sometimes eat it. Gulls, ravens, and crows may eat the loose tissues, e.g., in the eye sockets. Bodies in water are exposed to injury from lampreys, crabs, lobsters, water beetles, and mackerel. Eels use the hollows of the body as hiding places, but do not eat it to any extent. Starfish cause injuries by attaching themselves firmly, the injury taking the same pattern as the starfish.

Other Indications of Time of Death

In certain cases, the pathologist can draw conclusions from the stomach contents and intestines regarding the time of the last meal, its quantity, and composition. The investigator can assist the pathologist by relaying any information found with regard to the composition of the last meal.

Watches and clocks may be valuable guides in determining the time of death. A clock may stop when it receives a blow during a struggle or is moved from its position by an explosion or shot. When investigating a suspicious death, the police officer should therefore give careful attention to any clock found at the scene, indicate the position of the hands of the clock in the report of the investigation, and see if it has stopped from external action. If clocks or watches are running, it should be noted whether they are showing the right time; the time at which they finally stop should be determined. In the case of alarm clocks the report should state the time for which the alarm was set and whether the ringing mechanism has run down or the alarm has been shut off. When a more detailed investigation is required, a watchmaker should be consulted (Figure 16.11).

Watches of older construction generally stop immediately upon contact with water, but a watch provided with a tight-fitting case and glass can run longer before stopping. Watertight watches run for a long time underwater. If a pocket or wristwatch is found on a body, the police officer should not carry out any further examination of it or perform

[1] The web page for the American Board of Forensic Entomology is found at: http://www.missouri.edu/~agwww/entomology/. Another useful web page on forensic entomology can be found at: http://www.forensicentomology.com/index.html.

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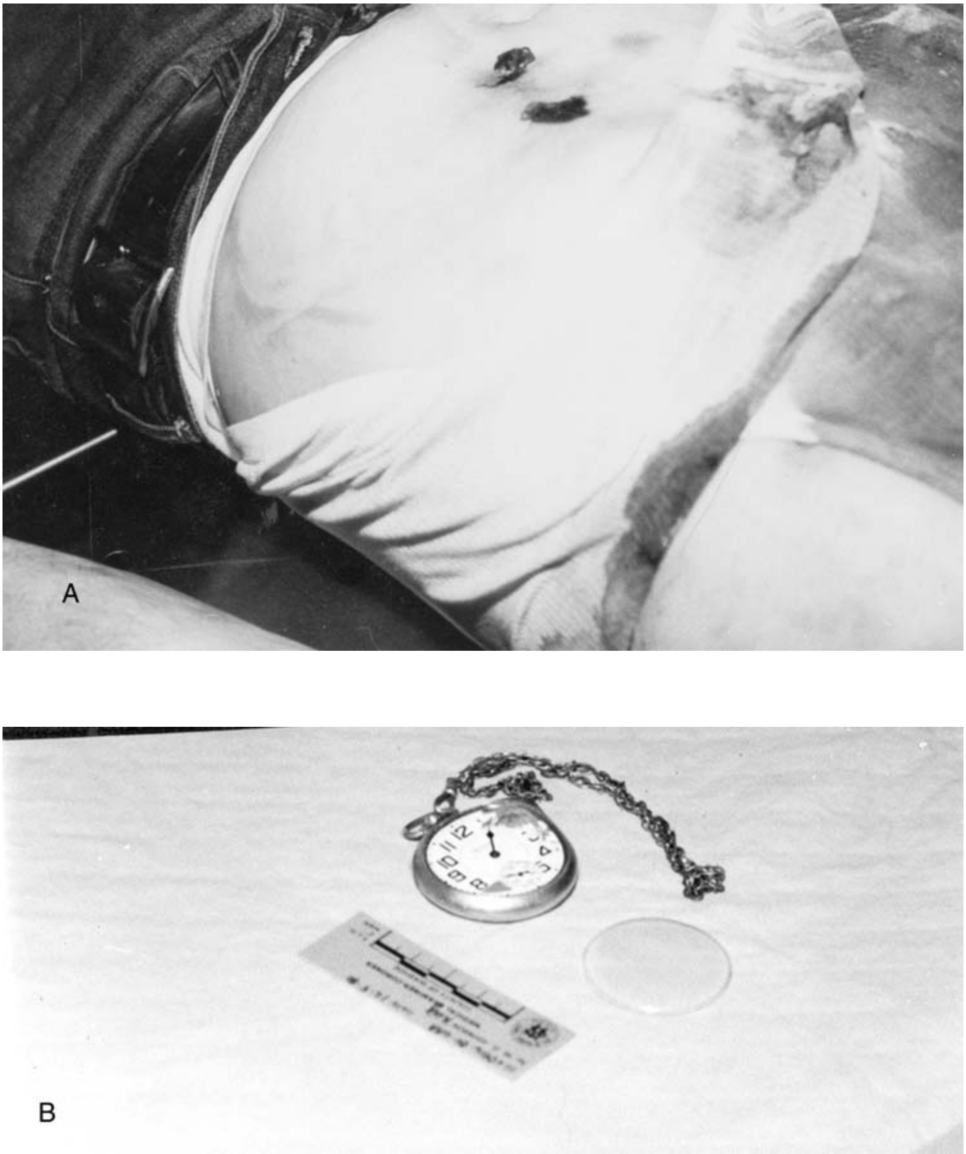

Figure 16.11 A pocket watch absorbed the impact from a slug aimed at the decedent's torso. The abrasion on the decedent's abdomen (A) is from the watch; the slug is shown in the position in which it was found. The watch (B) shows the small hand between 1:00 and 2:00. The time that the witnesses placed the defendant at the decedent's home was approximately 1:30. *(Washoe County Coroner's Office, Reno, Nevada.)*

any tests but should consult a watchmaker. Digital watches and clocks, unfortunately, do not lend themselves to these techniques.

In investigating cases of suspicious death, certain conditions can give a good indication for an approximate determination of the time of death. This may be obtained from papers and letters in a mailbox, dated receipts, food materials' state of decomposition, dampness of laundry that has been hung up, dust on furniture, cobwebs, evaporation of liquid in a glass, cup, or other vessel, flowers withering, drying in flowerpots, date on a calendar or diary, food product dating codes, etc.

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When a dead body is found outdoors, the growth of vegetation under and around it can be a good guide in deciding the time when the body began lying there. Flowering plants may be buried and thus may indicate closely the time of burial. The coloring matter of plant leaves under the body undergoes certain changes; chlorophyll generally disappears after a week. A good indication can also be obtained from a comparison between the stage of growth of plants under the body and of similar plants in the vicinity. When a body has lain in one place for a considerable time, in favorable cases, the decaying vegetation underneath can indicate the time of year when the body was placed there. If the weather has changed, the amount of moisture under the body, compared with that in the surrounding area, may give some information. When a dead body is found in snow, its position in relation to layers produced by successive snowfalls should be determined accurately.

Some guidance may also be obtained from the extent of decay of clothing. Cotton fabrics decompose after 4 to 5 years; wool after 8 to 10 years; leather and silk only after 20 years or even longer.

The Autopsy

The investigator present at the crime scene should also be present at the autopsy. The investigator's attendance is desirable so that the forensic pathologist can be briefed about pertinent finds at the crime scene, as well as other information that will be of value in the examination. Additionally, information uncovered at the autopsy and communicated verbally by the pathologist to the homicide investigator will be helpful in the criminal investigation.

Besides photographs taken at the crime scene, the victim should be photographed at the morgue clothed and unclothed. The pathologist and investigator should be present and carefully examine the victim prior to undressing the body. Color photographs should be taken of all pertinent details: the overall appearance of the body, close-ups of the face, injuries, ligatures and marks, and the like. A scale should be included in the photographs.

Care should be taken in undressing the body. It should be undressed in the usual way; the clothing should not be cut, if possible. If cutting is required, care should be taken not to cut through bullet holes, knife cuts, tears, or stains. The garments should be packaged separately. If they are wet or blood-soaked they should be allowed to air-dry at room temperature and away from direct sunlight. The clothes should be hung up to dry with paper draped loosely around the article of clothing to catch any trace material that might fall or be carefully spread out on clean paper. It is important that bloodstained articles be properly preserved in order to obtain the most from forensic biology testing (see Chapter 8 to review preservation procedures for bloody evidence).

After the clothes have been dried, they may be packaged for submission to the crime laboratory. The investigator and pathologist should be careful to establish a chain of custody of the evidence so it can be admissible in court. Trace evidence present on the victim and the clothing should not be overlooked. Body bags used to carry the body from the scene to the morgue should be carefully inspected for debris and trace material. Any trace evidence found on the body should be removed and properly packaged. Traces noted on the clothing should be removed and packaged only if the evidence might be lost in transit to the laboratory; otherwise the traces should remain and be packaged with the clothing. Investigators at the scene may wish to leave written instructions for the forensic

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pathologist or assistant responsible for collecting trace evidence from the body when it arrives at the morgue. Of course, it is strongly recommended that homicide investigators make every attempt to be present at the autopsy and to discuss the case with the pathologist.

Following photography, initial examination, and undressing, the body should be fingerprinted. The surface of the body should be searched for bloody fingerprints. The techniques earlier described to obtain latent fingerprints from skin may be attempted on promising areas. Fingernail scrapings and hair samples should routinely be taken from all murder victims. A blood specimen should be collected during the actual postmortem examination.

The body should next be washed and rephotographed. Identity photographs of the victim's face should be made at that time. The entire body, including injuries, should again be photographed. Photographs taken during the remainder of the autopsy may be of value in the subsequent investigation and should be encouraged. If the victim died as a result of a shooting, x-rays are necessary to identify and locate the bullet fragments, jacket, etc.

The purpose of the autopsy is to establish the cause of death as well as the circumstances immediately surrounding the time of death. The homicide investigator uses this information together with information gathered from other sources in the solution of the crime. Two factors will have a significant bearing on the outcome of the case: the degree of care and skill in which the postmortem examination is conducted and the level of cooperation between the investigator and forensic pathologist.

The remainder of this chapter discusses the various types of injuries by different modes encountered in death investigations.

Injuries from External Mechanical Violence

Injuries from external mechanical violence are made by blunt or sharp instruments and may consist of abrasions, contusions or bruises, crushing wounds, or bone injuries.

Abrasions

Abrasions generally result from violence applied obliquely, which scrapes off the top layer of the skin, but they can occur from violence directed straight against the body, and may reproduce the shape of, say, the radiator of a car or the details of a weapon's surface. As a rule there is no bleeding. In a favorable case it is possible to decide in which direction the body received the violence and, with some degree of certainty, what caused the injury. In general, it is very difficult to determine whether scraping of the epidermis was produced before or after death, although postmortem drying may leave a characteristic yellow parchment-like appearance. Removing or undressing the body must be carried out with care so that no injuries are produced.

Included in abrasions are fingernail marks that are narrow and usually somewhat curved. If the fingers slip, the nails produce scratches or tears.

Contusions or Bruises

Contusions or bruises are injuries to the tissues and organs produced by blunt external violence and result from compression, usually against the parts of the skeleton lying underneath. The most usual type of contusion is an extravasation of blood; when this is close to the skin it is commonly called a bruise or black-and-blue mark. In extravasation, the blood comes out into the surrounding tissues and remains there, unable to get away

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to the outside or to the body cavities. A bruise or black-and-blue mark initially shows a swelling and has a reddish color; it then assumes a blackish-blue to bluish-red color, changing gradually to brownish with strong shades of green and yellow. In rare cases, a bruise resulting from a blow with a weapon will have the same form as the striking surface of the weapon. If a bruise is found on a dead body, it may be concluded with certainty that the injury was produced when the victim was alive. At the autopsy it is usually possible to determine whether a contusion has been produced some time before or in direct connection with the death. Only a pathologist can distinguish the livid patterns from bruises found on a dead body.

Contusions may occur at places other than those where violence was applied. For example, a blow against the back of the head can produce bruises around the eyes. Similarly, with an abnormal accumulation of blood in the blood vessels, as in cases of hanging or other forms of suffocation, bruises can appear in the face. Diffusion of blood may also appear in cases of poisoning and, in some diseases and infections of the blood, injury to the walls of the blood vessels.

Crushing Wounds

Crushing wounds occur most readily, with blunt violence, at those places where the skin is near the bones. They are characterized by irregular form, gaping and swollen edges to the wound, and often considerable bleeding into the surrounding tissues. The wound rarely takes the form of the object producing it, but an impression of the latter may be found. Sometimes a crushing wound is remarkably straight and even at the edges; this occurs when the skin breaks over the uniform edge of a bone or where it splits along a parallel fibered tissue structure. Such a wound may give the impression of having been produced by a sharp weapon. This type of wound can be detected with a degree of certainty because in deeper lying parts of it the walls of the wound are uneven and connected by bridges of tissue (Figure 16.12).

A crushing wound resulting from a blow on the head with a hammer or the head of an ax sometimes has the same form as the round or angular edge that produced it. If a blow of this type is so powerful that the weapon penetrates the cranium, the injury may have the same form.

When blunt violence is used against the body, it is possible for vital organs such as the brain, heart, lungs, liver, spleen, and kidneys to be damaged without any visible external injury. Bite wounds are a special form of crushing wound. The form of a bite wound may reproduce the arrangement of the perpetrator’s teeth.

Bone Injuries

Bone injuries may result from blunt external violence, for example, directed against the head. If a bone injury has occurred during life, diffusion of blood is generally found near or around it. Blunt violence against the cranium may produce a fracture. The direction of the crack may make it possible to determine the direction from which the violence came.

Injuries from Sharp External Violence

These may consist of cutting wounds, stab wounds, or chopping wounds.

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Figure 16.12 (A color version of this figure follows page 256.) Using a honeydew melon (A) to simulate a skull, tests with different hammers (B) suggested one that left a similar shape and dimensions in the victim's skull. *(Norman D. Sperber, DDS, San Diego, California.)*

Cutting Wounds

Cutting wounds have even, sharp edges. When the direction of cutting is across the direction of the fibers of elastic tissue, the wound gapes; when the direction of cut is parallel to the fibers, the edges of the wound generally lie against one another. Often it is difficult to decide whether a cutting wound occurred during life or after death because contusion injuries, which may form a guide in such cases, are not found around the wound. As a

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rule a cutting wound is deepest at the place where the cutting object was first applied. The wound leaves hardly any detailed information about the instrument that caused it.

In cases of suicide, the cutting force is generally directed against the throat or insides of the wrists and, sometimes, against other parts of the body. The intent of the suicide is usually to produce bleeding by cutting the arteries. In cases of suicide there may be one or several cuts, generally not of a dangerous type, parallel or running into one another, known as "hesitation cuts." If it is established that such surface cuts were produced before the final fatal cut, it is quite certain that the case is one of suicide; the surface cuts were made because the suicide did not know how much force was required to produce the fatal cut or feared the pain anticipated from the act. The police officer should not, however, draw hasty conclusions from superficial cuts that give the impression of having been made before the fatal cut.

Nothing prevents a murderer who has knowledge of these circumstances from adding superficial cuts after making the fatal one in order to give the impression of suicide. Only a pathologist is competent to decide in what order the cuts were made. In some cases of suicide the individual has made a number of trial cuts at places other than the one where the fatal cut was made. Such trial cuts, which as a rule are superficial, may be situated on the temples, arms, or legs. With an active or desperate suicide the first cut may be a fatal one, but that does not prevent the victim from adding a number of others before losing consciousness.

A suicidal person generally cuts in the direction where the cutting hand is placed. When a right-handed person cuts his or her throat, the position of the cut is generally on the left side of the throat; if the victim is left-handed the position is reversed. In connection with cuts in the throat, it should not be forgotten that a murderer might handle the weapon in exactly the same way as a suicide, if the murderer overcomes the victim from the rear.

In cases of suicide by cutting the throat incisions made in the free hand can easily be confused with defense injuries. Such wounds may be produced when the suicide stretches the skin of the neck with the free hand so that the weapon can penetrate more easily. Wounds may also be produced from holding the blade in order to be able to put more force into the cut.

In cases of death from cutting the throat, there is reason to suspect murder when the position of the wound does not correspond with a natural hold on the weapon, or the direction of the wound does not correspond with the right- or left-handedness of the victim. Murder may be suspected if the wound is very deep or if it is irregular. Special attention should be given to the possible occurrence of fingernail marks and scratch injuries that would be produced if the murderer held the head of the victim fast, and also to the presence of defense injuries on the hands and arms. If cuts are on the clothing, it may be murder because suicides generally lay bare the part of the body that they intend to cut.

Stab Wounds

Stab wounds are generally produced by a knife, dagger, or scissors, but may also result from other weapons, e.g., an ice pick, awl, pointed stick, and similar items. If a stab wound has been produced by a sharp knife or dagger, it is not possible to determine the width of the blade from the size of the surface wound because the wound channel is generally wider than the weapon, especially if it is two-edged. When the weapon is stuck into the body, the edge has a cutting action, so the surface wound is considerably longer than the width of the blade; when the weapon is withdrawn, it usually assumes a different position, so

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the wound is enlarged still further. The weapon may also be turned when withdrawn, so the surface wound becomes curved or angular. A knife with a thick back produces a wedge-shaped wound.

When stab wounds are produced by a weapon with a blunt point, the outer wound is smaller than the cross-sectional width of the instrument. In such cases, when the weapon is driven into the body, the elastic skin is actually pressed inward and stretched until it breaks. When the weapon is withdrawn, the skin returns to its normal position and the external wound contracts. If the weapon is cone shaped and rough, the skin around the wound may break in radial cracks.

With a stab wound in the heart, death may not occur immediately. In some cases people have survived a wound in the heart.

A suicide attempt by stabbing is generally in the region of the heart or, in some cases, in the stomach or other parts of the body. It is often found that a number of stab wounds are concentrated in a small limited region, i.e., around the heart. In such a case the suicide has stabbed the body several times without result, in the same way described earlier in "Cutting Wounds." One fact that indicates suicide is clothes that are unbuttoned or have been taken off. In suicide the stab is generally directed into the body at right angles.

In cases of murder the stab wounds are usually not concentrated in one place but scattered, especially when the victim has attempted self-defense. Knife stabs are, as a rule, directed in an oblique direction against the body, with the exception of cases in which the victim was lying down. A number of deep wounds and wounds in the back indicate murder. If the victim tried self-defense, the wound channel may be curved owing to the body being in a certain position when it received the stab. At the autopsy it may be found that a wound channel does not go right through because the position of the body was such that the muscles were displaced from their normal position when they were penetrated. In such a case, the position of the dead person when he or she was stabbed can be reconstructed.

Chopping Wounds

Chopping wounds are generally produced by an ax or, more rarely, by a blow with some other edged tool, e.g., a heavy knife, sword, broadax, or the like. Usually the wound is similar to a cutting wound, but is easily distinguished from the latter by a ring of contusion injury around the wound, and also by the crushing effect produced when the blow meets bony parts. If the edge of the weapon is deformed, tool marks may appear in these bony parts, which can, in favorable cases, lead to the identification of the weapon that was used.

When a blow from an ax or other edged weapon has killed a person, murder can nearly always be assumed. In cases of murder or other violent death from an ax, the wounds are generally in the head and in different directions. In certain cases they may have the same direction, for example, when a sleeping person, or one who is held, is struck. Usually the criminal first delivers a few blows with the head of the weapon before completing the job with the edge.

Suicide with an ax has occurred, but is rare. Generally the suicide directs the weapon against the forehead and crown of the head. The first blow is relatively light and only produces superficial injuries that are not fatal; then the suicide continues by putting more force in the blows and possibly using the weapon with greater accuracy so that fatal injuries are produced. The wounds have a typical appearance that cannot be mistaken — they are directed from the forehead to the back of the head, approaching one another at the forehead.

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Figure 16.13 (A color version of this figure follows page 256.) During a violent struggle, the victim's left thumb (A) sustained a defense wound. In the ensuing struggle the victim's blood was deposited onto the suspect's shirt (B). The suspect claimed that the blood was the result of his attempt to save the victim. Close examination of the lower left side of the shirt shows blood stains that look remarkably like the victim's attempt to grab the shirt with his bloody left hand (C). (*Los Angeles County Sheriff's Department.)*

Marks or Damage on Clothing

These can be very significant in the reconstruction of events. In cases of blunt violence, an impression of the weapon causing the injury may be found on the clothing, while headgear may show a clear mark of a hammer or other tool. In the case of a blow against the head, the tool used may even chip out a piece or corner of the headgear; this piece will have the same form as the striking surface of the weapon. An impression in the corresponding part of the outer clothing may show that a bruise on the body has resulted from a kick or from trampling. Impressions in clothing may be mixed with dust, dirt, or other contamination from the object producing the injury. Injuries to the clothes may be a good guide for the reconstruction of the course of events in the case of injury from cutting violence. In stabbing cases the hole in the clothing may have a position different from that of the wound. A victim who has been stabbed may lift his arms in self-defense so that the clothing moves out of its usual position on the body; in such cases the defensive position can be reconstructed. A garment perforated in several places by the same stab indicates creases in the clothes.

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Figure 16.13 (continued)

Defense Injuries

Self-defense wounds are often found on the hands and arms of the murder victim. If a knife was used, the insides of the hands may be badly gashed from gripping the blade of the knife. Stab and cut wounds may be produced on the arms and hands when a victim attempts to parry an attack. When a crushing weapon is used in a murder, the hands of the victim may be badly injured from putting them on the head to reduce the violence of the blow. Among defense injuries are also included those that occur when the victim attempts self-defense by attacking, e.g., knuckles injured from using fists against the criminal or nails broken from scratching.

Firearm Injuries

These must be considered as a special group of injuries because the investigation differs substantially in important respects from the investigation of other injuries. One might think that because a police officer should not touch a wound, it is not necessary to have a detailed knowledge of firearm injuries on a body. They are, however, so frequent and so important that whenever the pathologist cannot arrive in a reasonable time the police officer should be prepared to make personal observations and to take whatever measures are necessary. Because firearm injuries are frequently covered with blood, it is often impossible for a police officer to distinguish between a gunshot injury and one produced by other external mechanical violence. Under these circumstances it is necessary to wait patiently for the arrival of the pathologist; this holds even when it is important that the

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Figure 16.13 (continued)

type of injury be determined at an early stage. The police officer should never probe in or around a gunshot wound because that may destroy or reduce the chance of the expert being able to determine the type of injury and to reconstruct the course of events.

Bullet Injuries

When a bullet strikes the body, the skin is first pushed in and then perforated while in the stretched state. After the bullet has passed, the skin partially returns to its original position; the entry opening is drawn together and is smaller than the diameter of the bullet. Slower bullet velocities result in smaller entry openings. The bullet passing through the stretched skin forms the so-called "abrasion ring" around the entrance opening because the bullet slips against the skin that is pressed inward and scrapes the external epithelial layers. The skin in the abrasion ring becomes conspicuous by drying after some hours. In a favorable case, rifling marks on the bullet leave such a distinct mark in the abrasion ring that the number of grooves in the rifling can be counted. The combined section of the abrasion ring and entrance opening corresponds to or slightly exceeds the caliber of the bullet. When a bullet strikes the body squarely, the abrasion ring is round and when it strikes at an angle it is oval.

Along with the abrasion ring, another black-colored ring, the "smudge ring," often entirely covers the abrasion ring. This does not contain any powder residues or contamination from the bore of the firearm, but consists wholly of small particles originating from

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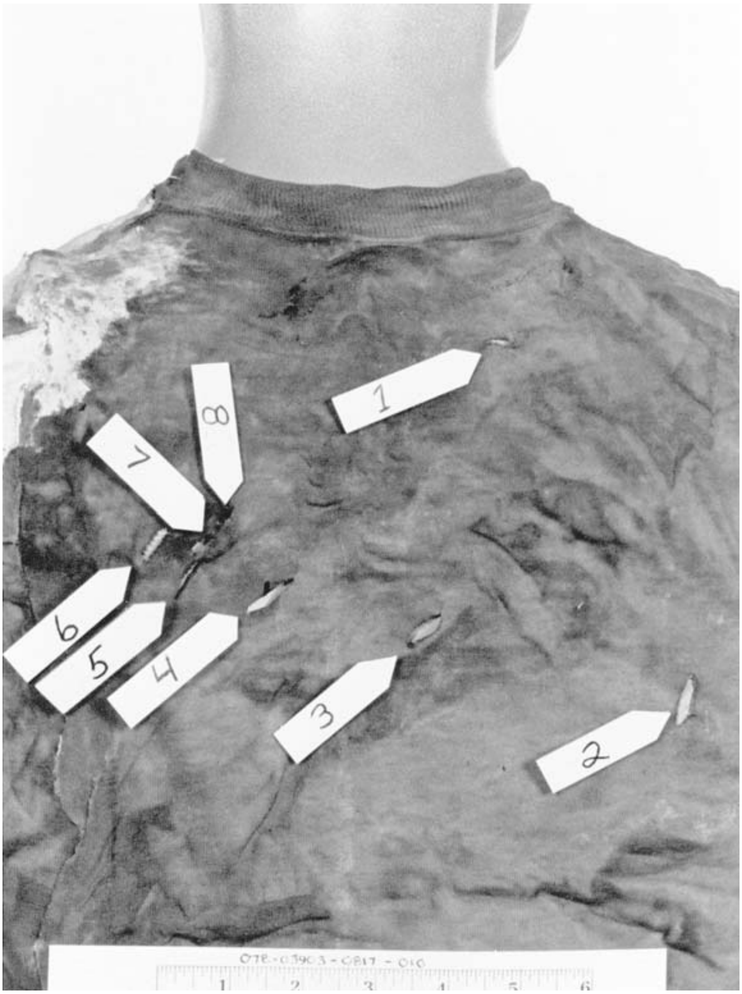

Figure 16.14 A bloodstained undershirt was placed on a mannequin to show more clearly the location of tears caused by stabbing. *(Los Angeles County Sheriff's Department.)*

the surface of the bullet. The smudge ring, or "bullet wipe" may be absent in the case of clean-jacketed bullets or when the bullet has passed through clothing.

A bullet passing through the body forms a track that is usually straight, but can also be bent at an angle in an unpredictable manner if the bullet meets or passes through a bone. Thus determining with certainty the direction of the weapon when the shot was fired is not possible from observation of the entrance and exit openings. The pathologist must calculate this direction from the results of the autopsy. The velocity of the bullet has a great influence on the appearance of the track; straight tracks indicate a high-velocity, bent and angular ones a low velocity.

In gunshot injuries in soft parts of the body, especially in the brain, the bullet can produce a considerable explosive effect, which is greatest with unjacketed or soft-nosed bullets from high-velocity firearms. Such a bullet may split into several parts, each of which forms its own track, and thus several exit wounds may be present. When such a bullet strikes the head, large parts of the cranium can be blown away and the brain scattered

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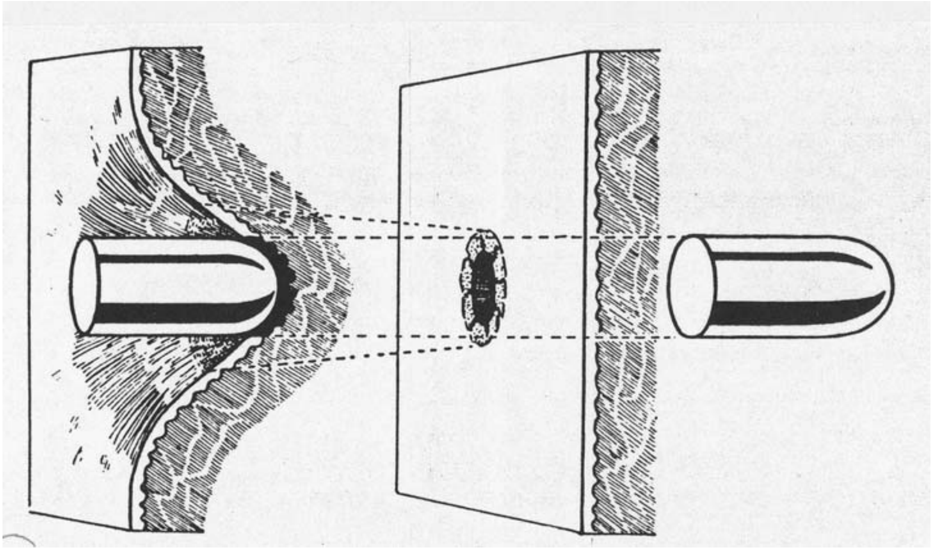

Figure 16.15 Diagrammatic representation of a bullet penetrating the skin. The skin is pressed inward, stretched, and perforated in the stretched condition, after which it returns to its original position. The entry opening is smaller than the diameter of the bullet. Immediately around the opening is the abrasion ring, caused by the bullet's rubbing against this part of the skin and scraping off the external layer of epithelial cells.

around. A soft-nosed bullet that, before hitting the body, is split by striking against a tree branch can produce a number of irregular entrance holes.

A shot through the head is not always fatal. To be immediately fatal the bullet must produce a bursting effect or injure a vital brain center. A shot through the brain that is not immediately fatal does not always produce unconsciousness. Even when a bullet has perforated the heart, the injured person can sometimes live for several hours, retaining some capacity for movement.

It is often difficult to distinguish the exit wound from the entrance wound, especially at long range with a metal-jacketed bullet, assuming that the bullet passes through the body intact. In a favorable case the exit wound may have a ragged appearance with flaps directed outward. To determine the direction of the shot with certainty in such a case, an autopsy is necessary. If the bullet has been damaged by its passage through the body or if there has been a bursting effect, then it is generally easy to determine the exit wound. This wound is often considerably larger than the entrance wound and shows a star-shaped, ragged character, with flaps directed outward. Note, however, that in contact shots the entrance wound may be ragged and star-shaped. A bullet that ricochets may strike with its side or obliquely and produce a large and uncharacteristic entrance wound.

Close and Distant Shots

It is very important to be able to estimate the distance from which a shot was fired. In many cases this fact is the only evidence available that can distinguish between suicide, a self-defense killing, manslaughter, or murder (Figure 16.17 and Figure 16.18).

In practice, a distinction is made among contact, close, and distant shots. A *contact shot* is one in which the muzzle of the weapon is pressed against the body when the shot

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is fired. In a *close shot* the distance of the muzzle is less than about 18 inches from the body, while a *distant shot* is one fired at a distance greater than 18 inches.

In the case of a contact shot against an exposed part of the body, soot, metallic particles, and powder residues are driven into the body and can be found there during the autopsy. Blackening, caused by soot and powder, around the entry opening is often absent. A contact shot against a part of the body protected by clothing often produces a powder zone on the skin or in the clothes, while soot, powder residue, and fragments of clothing are driven into the track. With a contact discharge, the entrance wound differs considerably from an entrance wound in a close shot or distant shot. When the shot is fired, the gases of the explosion are driven into the track; however, they are forced out again and produce a bursting effect on the skin and clothes. The entrance wound is often star shaped with flaps directed outward. It is also possible, in a contact shot, for the muzzle of the weapon to mark the skin, causing an impression that reproduces the shape of the muzzle of the weapon (Figure 16.19 and Figure 16.20).

A close shot produces a zone of blackening around the entrance wound of the track, on the skin or also on the clothes. Sometimes, the flame from the muzzle has a singeing action around this opening, with hair and textile fibers curled up. The zone of blackening is formed of substances carried along with the explosion gases.

When a cartridge is fired, the bullet is forced through the barrel of the weapon by the explosion gases. Only a small amount of this gas passes in front of the bullet. The combustion of the powder is never complete even with smokeless powder, still less with black powder, and the explosion gases therefore carry with them incompletely burned powder residues, the amount of which decreases as the distance increases. Thus, in a close shot, a considerable amount of incompletely burned powder residue is found on the target. Together with this residue, the gases also carry along impurities from the inside of the barrel consisting of rust (iron), oil, and particles rubbed off the bullet. Metallic residues from the percussion cap and cartridge case also occur in the gases of the explosion. If the shot is fired at right angles to the body, the zone of blackening is practically circular; if it is fired obliquely the zone is oval. The extent of the zone of blackening is often difficult to determine by direct observation, so it is often better to photograph it using infrared-sensitive material, which intensifies the zone so that its extent is more easily determined. The zone of blackening gives valuable information for determining the distance from which a shot has been fired, which may be an important factor in deciding between murder and suicide. It is important that comparative test shots be fired with the *same weapon* and *same type of ammunition* as those used in the actual crime.

Close shots with black powder show marks of burning up to a distance of 4 to 6 inches and a distinct deposit of powder smoke up to 10 to 12 inches. Dispersed grains of powder embedded in the target may be detected even at a distance of 3 feet.

A *distant shot* is one in which none of the characteristics of a close shot can be detected (distance over about 18 inches). *Powder residues* occur on the object fired at in the form of incompletely and completely burned particles. A careful microscopic examination should precede any chemical examination because it is often possible to establish in this way the shape and color of unburned powder particles and to distinguish many kinds of powder.

Black powder, which consists of potassium nitrate, sulfur, and charcoal, is identified by the presence of potassium and nitrate in the entrance wound. Smokeless powder consists chiefly of nitrocellulose or of nitrocellulose with nitroglycerine and is identified by the

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Figure 16.16 Bullet entry (A) and exit (B) wounds to the head. *(Los Angeles County Department of Coroner.)*

presence of nitrite, which can be detected by various microchemical reactions. The grains of smokeless powder are generally coated with graphite and occur in many forms, e.g., round or angular discs, pellets, and cylinders.

Marks from Primers

At one time a primer generally contained a percussion composition of fulminate of mercury, stibnite (antimony sulfide), and potassium chlorate with a varying amount of powdered glass. Primers now have eliminated the mercury and the rust-forming products from the potassium chlorate. This has resulted in the replacement of the mercury fulminate by lead compounds, such as lead azide and lead styphnate (lead trinitroresorcinate), and in the replacement of the potassium chlorate by barium nitrate. Stibnite is still used, however, to a limited extent.

Thus in a chemical examination of a gunshot injury the metals that first come into question are barium, lead, and antimony. For example, determining the lead content of a bullet wound and comparing it with that obtained from a test discharge against a similar object with the same ammunition from different distances, quite reliable information

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Figure 16.16 (continued)

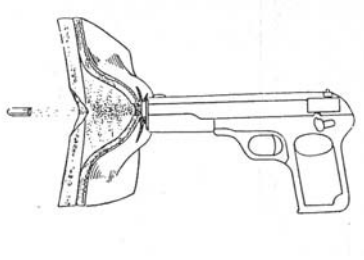

Figure 16.17 In a contact shot, the weapon is pressed against the head or the body. The gases from the explosion expand between the skin and the bones, producing a bursting effect and a ragged entrance wound.

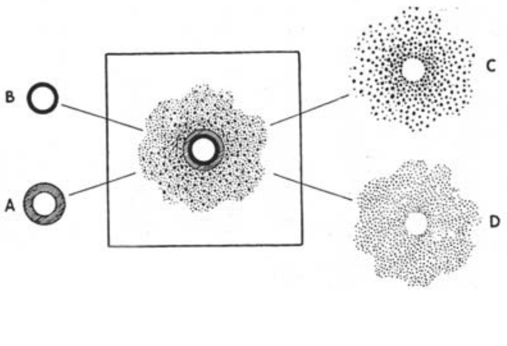

Figure 16.18 A diagram showing the marks that may be found around the entry opening of a bullet in a close shot: **(A)** contusion ring, **(B)** smudge ring, **(C)** grains of powder, and **(D)** deposit of powder residue.

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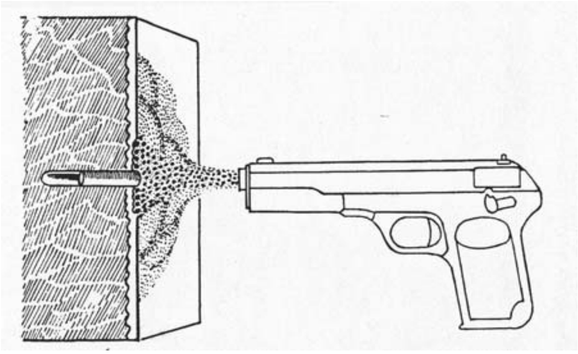

Figure 16.19 Close shot, short distance: incompletely burned powder grains and smoke deposits in the zone of blackening. The powder grains are concentrated immediately around the entrance hole.

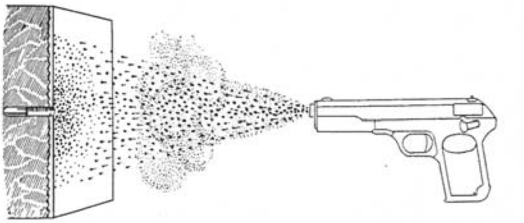

Figure 16.20 Close shot, greater distance than in Figure 16.19: unburned powder grains, but no smoke deposits, in the zone of blackening.

regarding the distance from which the actual shot was fired can be obtained in favorable cases.

Traces from Bullets

With injuries from plain lead bullets, such as those usually used in ordinary revolver ammunition, there is always a considerable amount of lead in the zone of blackening and in the smudge ring; in the latter it is even possible to detect lead from a distant shot. Lead traces from the surface of the bullet can also be found frequently in the exit hole. In some types of ammunition the bullet is greased; residues from these substances may be carried along with the bullet and found around the entrance opening. Metal-jacketed bullets, which are used chiefly for automatic weapons, consist of an inner lead core with an outer shell of some hard metal or alloy — the so-called jacket; the usual materials are copper, cupronickel, or brass. Traces of all these metals may be found in gunshot injuries.

Traces from Cartridge Cases

It is often possible to detect copper in the track and in perforated clothing up to a range of 6 to 8 inches. This comes from the cartridge case, from which the expansion pressure wears off small particles of metal. Large amounts of copper found in the dirt ring are considered a characteristic indication of a close shot. If, however, a copper-coated bullet has been used, then naturally no conclusion can be drawn regarding the possibility of a close shot because, in this case, even a distant shot shows a distinct amount of copper.

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Traces from the Barrel of the Weapon

Iron can be found in and around the entrance wound in a case of shooting with a weapon that has not been used for a long time because the barrel may be rusty. With automatic hand weapons, traces of iron can be detected up to a distance of 8 to 12 inches.

Injuries from Small Shot

With shotguns, the shot column can have a very concentrated effect at distances up to 1 yard. With a distance of up to 4 to 8 inches, the wound is practically circular. The greater the distance is, the more irregular the wound is. At a distance of up to 2 to 3 yards there is generally a central entrance opening and around it are single small holes from individual scattered shot. At a greater distance the shot spreads out more into small groups; at 10 yards the scattering can amount to 12 to 16 inches.

Damage to Clothes from Shooting

If a shot has passed through clothes, the position of the bullet hole should be compared with the direction of the wound track in the body in the same way as described previously in the section "Marks or Damage on Clothing."

Modes of Death from Shooting

In suicide the weapon is usually directed against the forehead, temple, or heart; a shot fired upward and obliquely into the mouth is quite common. In deciding if a case is suicide, an attempt should first be made to decide to what extent the victim could have fired the shot in the approximate direction given by the track. In the case of pistol or revolver shots against the temple it is necessary to know whether the deceased was right- or left-handed; however, a person might fire a weapon with the left hand but be otherwise right-handed.

It is an essential condition for the assumption of suicide that the victim be wounded by a close discharge and that the weapon lie in the proper position with respect to the body. If these conditions indicate suicide the question should not be considered settled because nothing prevents some other person from firing the shot under the given conditions and then laying the weapon down in the proper position.

A more certain indication is if injuries produced when firing a shot are found on the hand of the dead person in the form of a mark on the thumb or forefinger or on the web of the thumb. Such marks may result from the recoil of the slide of an automatic pistol. The most certain proof of suicide is found in the form of fragments of tissue and blood spattered from the wound onto the hand of the dead person. Although, in cases of suicide, the hand of the deceased may be blackened by powder, this cannot be taken as proof because the weapon could have been pressed in the hand after the shot was fired. It is also necessary to decide whether the body is in a natural position under the circumstances. A fairly certain sign of suicide is when the person has taken off any hindering clothes or exposed some part of the body before firing. No weapon near the body is a very suspicious circumstance, but hasty conclusions should not be drawn from that fact alone. In some cases a fatally injured person has traveled a long way before finally expiring or has thrown the weapon into a body of water. It has also happened that members of the victim's family have removed the weapon deliberately in order to create an appearance of murder, sometimes in the hope of escaping what they consider to be the disgrace of a suicide in the family.

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Figure 16.21 (A color version of this figure follows page 256.) This suicide shows the devastating result of a shotgun blast in the mouth, which resulted in the top of the head being blown away. *(Los Angeles County Sheriff's Department.)*

It is a certain indication that a person died through the action of some other person when the discharge was beyond arm's reach. "Arm's reach" means the length of the arm plus possible assistance from an extension in the form of a stick or some other convenient means of reaching the trigger of a long-barreled weapon. It is true that it is possible to commit suicide by means of a distant shot, but this requires arrangements of such a type (string-pulls, etc.) that there should be no difficulty in revealing the truth. When the fatal shot was fired from behind, it is safe to assume that it is not suicide. A suicide *could* fire a shot at the back of the head, but such a possibility is very far-fetched. The fact that the deceased has more than one injury cannot always be taken as proof that death was from the action of some other person. Cases occur in which a suicide has fired two or possibly a number of shots, each of which produced a potentially lethal wound, before becoming incapable of continuing the firing.

It is quite common for a person to be shot fatally by accident or through personal fault. During hunting, it is possible to slip or stumble on awkward ground, fall when climbing over a gate or other obstacle, or drop the weapon, whereupon a fatal shot may be fired. In such cases, generally marks at the scene of the accident or marks on the weapon give a clear indication of what has happened. A fatal shot may also be fired accidentally when handling a firearm, e.g., when cleaning it. In such cases, the investigating officer

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should observe the greatest caution and not assume from the start that it was an accident. The victim may very well have committed suicide while giving the incident the appearance of an accident or a murderer may also simulate an accident.

The police officer who carries out the investigation of a fatal shooting must not attempt to carry out any experiments that impinge on the responsibilities of the pathologist or criminalist. However, it may be necessary to undertake precautionary measures in connection with evidence that for some reason may be exposed to destruction. It has been stated before that, in and around a gunshot wound, traces of incompletely burned powder residues, of metals from the primer, cartridge case, and bullet, grease and dirt from the bullet and from the barrel of the weapon, as well as other such evidence, may be found. These marks may be of decisive significance in deciding, for example, the distance of the shooting; therefore, they must be protected as much as possible. In cases in which the bullet has gone through the clothes there is always the risk that evidence may be destroyed by rain or by moving the dead body. The police officer should therefore protect such evidence against destructive action by any suitable means, for example, by covering the actual place or, in suitable cases, by tying or pinning loose layers of clothing in a particular position. If there is any risk that the bullet hole in the clothes may become soaked with blood when the body is moved, the police officer must find some method of preventing it.

The hand that holds the firearm at the instant of firing can become blackened by powder in the area of the web of the thumb and on the thumb and forefinger. The deposit of powder smoke produced in this way can be identified chemically. Wrapping the deceased's hands in clean paper bags should protect them for later examination in the morgue.

Explosion Injuries

Explosion injuries are a variation of gunshot injuries. An explosive charge contains metal parts or is enclosed in a metal container that breaks up, e.g., a hand grenade; when it fractures metal objects, stones, or the like in the immediate vicinity, the fragments thrown off have an exceptionally great force that quickly decreases. When such pieces from an explosion hit a nearby body they can produce very severe damage. A small splinter of only a few millimeters in diameter can perforate the brainpan. When it penetrates the body, it bores a wound channel that can easily be mistaken for a bullet track. The energy in a fragment from an explosion decreases so rapidly that generally it is not able to penetrate the body. At close quarters, air pressure alone can cause fatal injury.

The fatal effect of an explosive charge is limited to the immediate vicinity; at a greater distance air pressure may cause injury from falling. Another way of committing suicide is to detonate dynamite in the mouth. The effect of such an explosion is generally that the head is torn away, while the skin of the back of the neck, with adhering bone and soft parts, is left on the neck. Suicide by explosion in the mouth can be carried out with nothing more than a blasting cap. In this case the injuries are to the throat and breathing organs. Generally, no damage is visible in the face; the lips and the skin of the face remain uninjured. Suicide has also been achieved by an explosive charge placed on the chest, in which extensive lacerations are produced.

The police officer should remember that wounds should be photographed, even when they are on a living person. The officer should therefore try to contact the doctor who has treated an injured person in order to discuss the possibility of photographing. This should

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not be delayed too long because a wound changes its appearance as it heals or is altered by therapy. Especially in the case of bite wounds and wounds of which the form reveals the character of the weapon or instrument, it is important that photographing should be done before a scab forms or an operation becomes necessary. A scale should always be laid next to the wound.

Death by Suffocation

The actual mode of death may be by hanging, strangulation, by hand, ligature, covering the mouth or nose, blocking the larynx or windpipe, crushing to death, or drowning.

Hanging

A mode of death in which a cord is placed around the neck and tightened by the weight of the body constitutes hanging. The effect of hanging is that the blood circulation to the brain ceases very quickly, which produces immediate unconsciousness; at the same time the air passages are closed up so that respiration ceases. The action of the heart may actually continue so that death occurs only after some minutes. With violent modes of hanging, injury may be produced to the vertebrae and spinal cord. The noose need not be very tight because only a small part of the weight of the body needs to be taken up for the hanging to be effective; the body does not need to hang free. The effect is the same if the hanging occurs with the body supported in a leaning, kneeling, sitting, or lying position. No one can escape from a tight-drawn noose once hanging in it because vagal inhibition occurs rapidly. This has been shown by a number of cases of persons who wished to try the effect of a hanging without any intention of completing it — they found themselves unable to recover from their situation. Thus children have been killed by hanging when, from curiosity, they wanted to test a hangman's noose. Similarly, in some cases a hanging situation has been arranged in order to obtain a perverse sexual stimulation. The commonly held view that death by hanging may be preceded by an erotic sensation is, however, certainly incorrect.

In suicide by hanging, quite frequently the rope breaks and the suicide falls down, but subsequently repeats the hanging with another rope and possibly at another place. This may necessitate tedious investigations because the suicide may have contracted bleeding injuries that were caused by the fall or when, after the unsuccessful attempt, he or she wandered around in a daze. In such a case, wounds, marks of blood, and disorder at the scene might be incorrectly interpreted as signs of a struggle.

The rope used is generally slender cord, e.g., a clothesline, but other objects may be used, for example, belts, suspenders, towels, scarves, thick shoelaces, etc. After hanging a typical mark on the neck is usually found: the so-called hanging groove. The broader and softer the noose, the less clearly the hanging groove shows. This is also the case when some part of the clothing comes between the noose and the neck. As a rule, however, the groove is distinct and full of detail, and it is often possible to distinguish marks of twisting, knots, and irregularities, while the width of the cord used can be calculated quite accurately.

The hanging groove generally has a typical appearance. The greatest pressure is exerted opposite the suspension point, i.e., if suspended from the back of the neck, the noose, if it is sufficiently thin or narrow, on the front side may have pressed in so deeply that it lies almost concealed by a roll of flesh. The groove then runs upward at an angle around the side of the neck, becomes less marked, and finally fades away as it approaches the back of

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the neck. The edges of the groove are generally puckered in the direction in which the cord slipped when the noose tightened. When hanging occurs in a lying or inclined position the groove may be more horizontal, which gives it a certain similarity with a strangulation groove, from which it can easily be distinguished because the hanging groove is less marked and disappears at the back of the neck. In cases of strangling in which the criminal's hands were held between the loop and the neck, the groove also disappears in the direction toward the hands. In general, however, the fingernails or knuckles produce such a great pressure against the neck that contusions appear in the skin. In rare cases, the noose may be applied at an angle on the neck or at the back of the neck, but the effect intended is still obtained because the large arteries of the neck are compressed effectively even when this method of hanging is used. Sometimes the noose may slip upward after the first tightening, whereby two or more hanging grooves are produced. This may give rise to suspicion of a crime, but generally the pathologist finds no difficulty in elucidating the actual circumstances.

It can happen that a hanged person's fingers are found between the noose and the neck. This was not due to attempting to loosen the noose, but rather to the fingers not having been removed when the noose tightened.

On the skin of the neck, dead persons may show marks that can easily be confused with hanging grooves. Articles of clothing pressing against the neck can produce such marks. On bodies that have been in water for a long time or that are undergoing decomposition, the hanging groove may have disappeared.

Murder by hanging must be considered an extremely rare occurrence that could be used only against children or persons who are unconscious or unable to defend themselves. In such cases, it is to be expected that the victim will show injuries other than those that occur from hanging. A murderer may attempt to give the appearance of suicide by hanging up the body after the onset of unconsciousness or death. If this is done by hoisting up the body, distinct clues are usually present on the supporting object and on the rope. For example, a branch of a tree may show such a clear mark of rubbing on the bark that it is not difficult to elucidate the actual circumstances — especially when the rope has also slipped sideways. On the part of the rope that has lain on and slipped against the support, the fibers are always directed upward against the latter.

Persons who have committed suicide by hanging sometimes show other injuries, which alone could be fatal. In such cases hanging has been employed after an unsuccessful attempt to commit suicide in another way. Such cases are easy to distinguish from those in which hanging is the final phase in a murder. Conditions generally give a clear picture of the course of events.

When a body is hanging free but there is no jumping-off point, such as a chair, table, step, stone, or stump in the vicinity, then there is every reason to suspect murder. In such cases, the scene must be examined carefully in order to determine whether it was possible for anyone to have climbed up to the point of attachment. With trees it is easy to find marks of climbing, e.g., twigs broken off or leaves, bark, or moss torn away, and similar traces should be found on the clothing of the dead person. An easily removable starting point, e.g., a chair, may actually have been removed by mistake before the arrival of the police.

In cases of hanging, livid stains are strongly marked on the feet, legs, and hands, and also immediately above the hanging groove. If such marks should be found on the back of a freely hanging body, for example, there is a question of the hanging having been done some time after death. The same question arises in a case when the arms or legs are bent

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Figure 16.22 Strangulation marks on the victim's throat (A) are similar to a suspect's belt submitted for comparison (B) and (C). *(Iowa Department of Public Safety.)*

because it is possible that the body may have been hung up after the onset of rigidity. After the rigidity has relaxed and the limbs have become straight, in some cases the wrinkles remaining in the clothes can indicate that the limbs were previously bent.

The presence of dirt on the clothes, e.g., leaves, parts of plants, soil, dust, or other material, that is not present at the scene of the hanging should be noted especially, as should the presence of blood, saliva, or urine flowing in the wrong direction. Such observations may give rise to suspicion of a crime. If the knots and noose are formed in such a way that it is doubtful whether the dead person could have made them, this must be considered a suspicious circumstance.

In suicide by hanging, right-handed persons usually place the knot of the noose on the right-hand side of the neck and left-handed ones on the left; reversal of these positions is suspicious. When investigating a case of hanging, the police officer should always have in mind that the autopsy can rarely decide between murder and suicide. As a rule, the course of events can be determined only from examination of the scene and police investigation.

Strangling

This is usually done by hand or with a cord. In strangulation by hand, death sometimes occurs almost immediately from shock, but usually the squeezing of the neck arteries is incomplete, so death results from interruption of the supply of air to the lungs.

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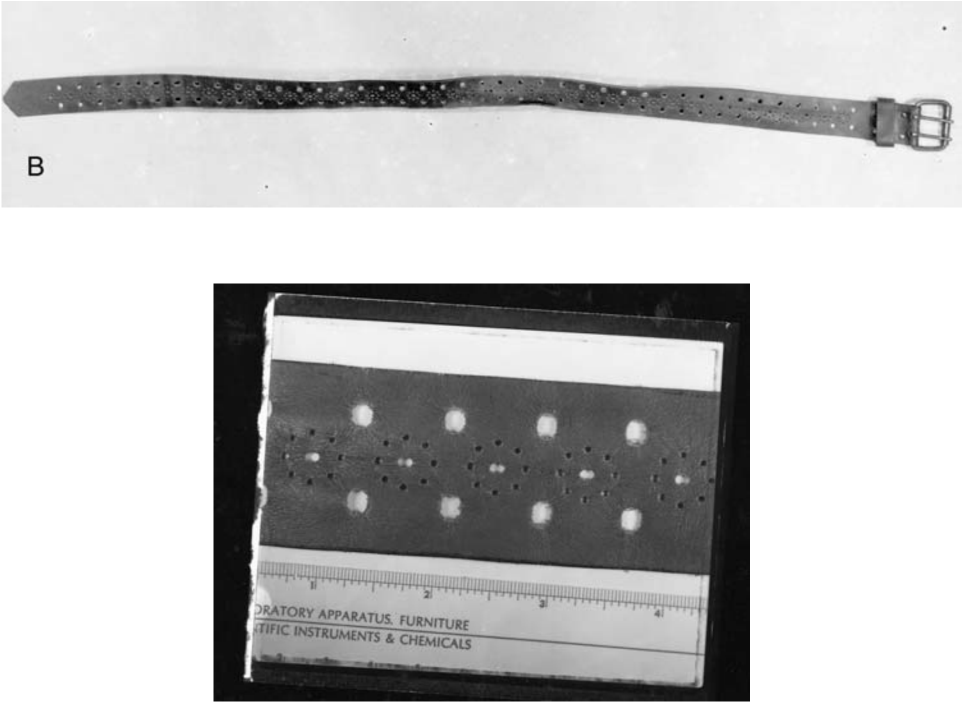

Figure 16.22 (continued)

In manual strangulation, typical fingernail marks are on both sides of the throat — from the fingernails on one side and from the thumbnail on the other. If the criminal is right-handed, the mark of the thumbnail is generally on the right side of the throat and on the left side if left-handed. There are often marks of several grips with the hands and abrasion of the skin where the fingers slipped. When death has occurred from shock, marks of nails may be missing. Strangulation is generally preceded by a struggle, so other injuries may be found on the body, usually scratches or bleeding on the face, as well as marks on the clothes.

Strangulation by hand has nearly always resulted from extraneous violence, i.e., from another person, although individual cases of suicide by strangulation by hand have occurred, with the suicide using a passive support for the hands so that the grip does not slip when unconsciousness occurs. In strangulation by ligature, death occurs in the same way as with hanging, but the strangulation groove generally has a course and appearance different from that of a hanging groove. Usually it goes around the neck in a horizontal direction or its back part may be situated somewhat lower down on the neck than the front part on the throat. In some cases it can, like the hanging groove, be directed back and upward. Usually the strangulation groove is located lower on the neck than the hanging groove.

Strangulation with a cord can generally be considered murder and defense injuries are usually found on the victim. Such injuries may be absent if the victim was overcome from behind or if a sleeping, unconscious, or defenseless person has been strangled. In a case in which the cord is left on the throat after the crime, it is generally fixed tightly by means of a number of turns and knots.

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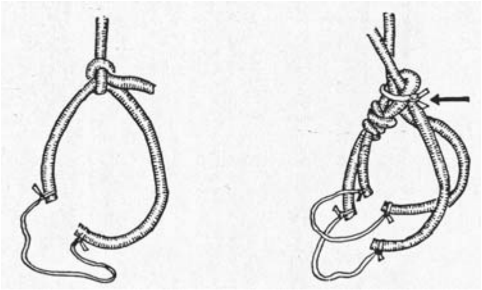

Figure 16.23 When a noose is removed from the neck of a body, the knots should not be disturbed or loosened. A fixed noose should be cut off and the ends immediately bound together (A). With a running noose, the position of the knot on the standing part (see arrow) is fixed, after which the noose is cut off. If the noose consists of a number of parts, they are cut and the ends are bound together (B).

Strangulation with a cord is a rare form of suicide. In cases in which suicide can be presumed, the strangling has been carried out with a running noose or by a scarf, rope, or the like, laid around the neck and knotted with a half knot, which is drawn so tightly that the neck arteries are compressed and unconsciousness supervenes. In both cases, one can expect that the hands will hold the noose fast after death or that their position relative to it will give clear evidence of suicide.

In investigating the scene of a hanging or strangling, the procedure to be followed should be the same as described previously for the investigation of murder in general. It is important that the police officer learn something about how the knots and nooses that occur in hanging and strangling are made. The formation of knots and nooses of a certain type often indicates whether or not the person hanged could have made them. When a knot or noose is of a type that could not have been made by the victim, then this must cause suspicion. There is a reason for being suspicious when, in a case of hanging or strangling, skillfully made knots and nooses have been found.

In describing knots and nooses the usual names may be used, but it is not to be expected that everyone who reads the report will be familiar with them; therefore, their construction should be reproduced by a diagrammatic sketch or sketches and they should also be photographed.

The noose should be examined immediately and the origin of the material used should be determined as quickly as possible. If one or both ends of the cord have been recently cut and the corresponding pieces are not found at the scene, this circumstance must be elucidated. Cut-off portions of the material of the noose are often found at the scene and, in such a case, scissors or another edged tool should be found in a likely place.

The ground under or around a hanged person must be investigated as soon as possible so that any evidence will not be destroyed. If the individual was murdered and then hanged in order to give the appearance of suicide, it is to be expected that distinct evidence will be found because considerable effort is required to hang up a dead body.

It is not uncommon for a person to commit suicide by hanging or strangling but take measures to give it the appearance of murder. These measures may consist of binding the legs and attempts to bind the hands, but this, especially the attempt to bind the hands, is easily detected. The individual may also have used some kind of gag, for example, a handkerchief that is pushed in or bound around the mouth.

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Knots in a hanging noose should not be undone or cut except in cases in which the victim's life may still be saved. Where it is possible, cut the rope or cord some distance above the head, loosen the noose, and pull it over the head.

Taking down a dead body must be done carefully so that no new injuries are produced. A convenient way is to raise the body a little so that the cord slackens and then cut the cord. The body is laid down and the noose is allowed to remain on the body. After the noose has been examined and photographed in its original condition, it is up to the pathologist to remove it during the autopsy.

The part remaining on the carrying object should be cut off at such a point that the knots are not altered or damaged, after which the cut-off parts are immediately bound together with string. If, for example, a cord is wound in several turns around the carrying object, a diagrammatic sketch of the arrangement is drawn as a reminder, after which the cord is cut and immediately wound around a similar object of the same diameter. When the line is composed of several parts (double or multiple), they are cut one by one and tied together in succession with cord or thread.

If it is suspected that a body has been hung up after death, the fibers in the cord must be protected, most conveniently by placing it stretched out in a long box so that it hangs freely. It can be held fast by loops attached by pins to the sides of the box.

What has been said about removing the hanging noose and strangling cord is the principal rule in cases in which it is to be expected that the life of the individual can be saved. If, however, the body has been dead for a long time (with certain signs of death present, e.g., putrefaction), the noose or cord is left in an untouched condition. The pathologist will examine it when making the postmortem examination. When, for any reason, the investigating officer must remove the noose or cord from such a body, the knots must not be deranged or loosened. A running noose can be loosened so far that it can be slipped over the head, but before that, this the position of the knot on the fixed part should be marked in some way, e.g., with chalk or by sticking in a piece of wire or winding a thread around it. If the noose is tight and cannot be passed over the head, it is cut off at a convenient point, generally at one side of the neck, after which the ends are immediately tied together with string. The same method is used for conditions in which the cord cannot be loosened and drawn over the head. In such a case, the position of the knot on the fixed part is marked, after which the cutting is done.

In cases of strangulation the ligature should be removed in the same way as a noose in the case of hanging. Special care should be taken not to cut through knots that may not be visible from the outside. In general, the ligature should be removed in such a way that the manner of application may be reliably reconstructed. This may require photography and simple sketches to illustrate the various layers and knots.

Because the knots in a cord may be required as evidence, they must be sealed in a suitable manner and the circumference of the constructive loops should be measured and recorded.

Blocking of the Mouth or Nose

This cause of death is rare and commonly occurs with newborn children. The stoppage may result either from a pillow or other soft object being pressed against the face or from a hand pressed against the mouth and nose. Death occurs from suffocation. Suffocation may also result from the mouth and nose being stopped with a handkerchief, piece of cloth, or cotton. When a pillow or other soft material is used there are no typical marks,

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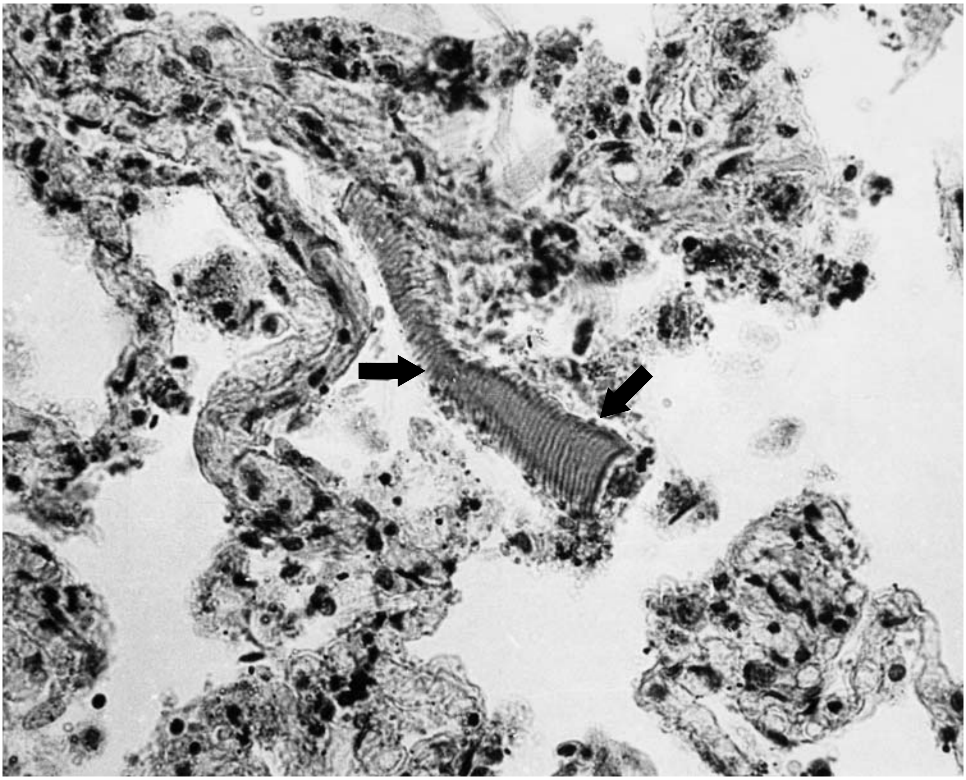

Figure 16.24 A photomicrograph showing striated muscle fiber in the alveola. A man was found dead on a road. At autopsy, the trachea and bronchi were full of stomach contents, suggesting that he died from asphyxia caused by vomiting. *(China Medical College, Shenyang, People's Republic of China.)*

but saliva or mucus may stick on the cushion and give some information about the course of events. It is possible that the suffocation may be accidental in cases in which a child turns onto his face. When suffocation is done by hand, scratches may be produced on the face. If the investigator suspects that the mouth and nose were stopped with cotton but later removed, an examination should be performed.

Elderly persons are sometimes murdered by blocking the mouth and nose with a soft covering. Murder can also result when a criminal, without intending to kill, has attempted to silence the cries of the victim in a case of rape.

Blocking of the Larynx and Air Passages

Blocking can occur, for example, when food goes down the "wrong way" or vomited stomach contents are unable to get out through the mouth. Infanticide can be committed by a finger pressed down in the throat of an infant causing suffocation. In this case there will be serious injuries in the mouth and throat.

Squeezing to Death

This can occur, for example, with a panic in a crowd, where the victim is squeezed or trampled or when a person comes under a heavy falling object or is buried by a fall of earth. The external injuries are generally considerable and easily interpreted. Squeezing to

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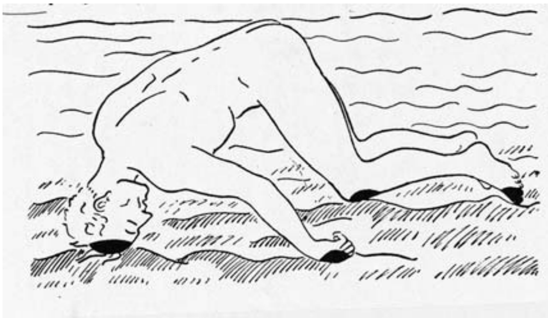

Figure 16.25 Body portions most exposed to injury when a body in water scrapes against a rough or stony sea bottom.

death can generally be considered an accident, but the possibility should also be kept in mind that an earth slide was arranged with the intention of murder.

Drowning

This is death due to liquid entering the breathing passages so that access of air to the lungs is prevented. The liquid need not necessarily be water; it may be mud, sludge, or other viscous material. Neither does the whole of the body need to be under the liquid. A person can drown when only the mouth and nose are under the surface. In a more general sense, the word "drowning" is used for every case of death in water, but this is incorrect because a death (for example, while bathing) may be due to heart failure, cerebral hemorrhage, or shock.

When a drowned person is drawn out of the water, white foam often comes out of the mouth and nostrils, where it forms white spongy puffs that can remain for quite a long time owing to the mucous contained in it.

When the cause of death is simply drowning, murder is comparatively rare and, as a rule, is committed only against children. If injuries are found on a drowned person that might have been produced by some other person, the drowning can generally be considered merely the final phase of a course of events involving murder or manslaughter. It can also happen that a criminal attempts to conceal the discovery of the crime by sinking the victim under water.

In cases of drowning, the question is generally whether it is suicide or accident. If the clothes have been removed or the place is chosen with the idea of avoiding the risk of bumping against a stony bottom, suicide is indicated. The opposite can indicate accident, as can marks of slipping found on stones at the edge of the water and injuries produced when the drowning person attempted a rescue, e.g., scraping of the skin of the hands and fingers or broken and torn nails.

The body of a drowned person may be tied in some way or heavy objects attached to it to make it sink and remain on the bottom. In such cases the police officer must proceed very cautiously with the investigation; it can be judged suicide, but suspicion of criminal acts should not be excluded.

A body lying in water is exposed to damage of many kinds. Propellers of boats may produce injuries. A body hit by a propeller can be cut in half. Bodies in water are also often damaged in the breakers offshore, against rocks, or when they bump against a stony and uneven bottom.

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Death from Electric Currents

Death from electric currents can occur from the electricity supply or from lightning. Visible injuries may be present at the points of entry and exit of the current — the so-called "current marks." If electric sparks or an arc touches the skin, the burn often shows the same form as the object producing it. When the direct injury is slight, characteristically formed fissures and figures indicate the passage of the current. The current marks are often round, sharply delineated, and light in color, or they may consist of edges or surfaces with charred skin. In severe cases the injury penetrates the underlying tissues of the musculature and bones. The surface of the skin may be impregnated with fine metallic dust, which emanates from the current-carrying object; this can be so great that it appears as a discoloration, sometimes gray or black and sometimes blue or bluish green. The metallic dust can be determined spectrographically. Considerable changes in the skin may also be produced at the point of exit of the current. At the points of entry and exit of the current, the clothing may be torn or charred; sometimes the damage consists of a number of small holes with burned edges.

Death from electric current may be accident, suicide, or murder. In some cases a trap has been set using house current, with the intention of murder.

Death from lightning is rare. When injuries are present on the body of a person assumed to have been killed in this way, they may consist of current marks on the neck and soles of the feet; the clothes may be badly torn; metal objects in the clothes may be fused together, burned, or thrown away, even in cases where no injury is apparent on the body. So-called lightning figures on the skin are not burning injuries but result from changes in the blood vessels. These arboreal marks generally disappear very quickly after death.

Violent Death in Fires

Only a pathologist can determine the cause of death and injuries on a person who has been burned to death. Death may be due to suffocation by smoke, carbon monoxide poisoning, or injury from falling beams, overturned furniture, falling walls, and so on. Generally, the person is already dead from such causes before the fire begins to attack the body.

Burned bodies usually lie in a distorted position, the so-called "pugilistic attitude" caused by the contraction of the muscles under the action of heat. The skin and soft tissues crack gradually; the cracks sometimes have quite even edges that can easily be confused with cut and stab wounds. The bones become more or less brittle, so breakages occur. In the inner parts of the skull the pressure may become so great that the bones of the cranium may shatter. The limbs are destroyed first as heat gradually chars the body. A greatly charred body sometimes has the form of a torso.

For complete combustion, very intense heat for a comparatively long time is required. A newborn baby can be burned away in an ordinary stove in 2 hours, but in order to consume an adult in the same time a temperature of 1250°C is needed, after which only certain bones remain.

Murder by burning does occur, but it can generally be assumed that the victim was subjected to other injuries before the fire was started. Disposing of a body by fire after murder is not uncommon. The criminal may in both cases have caused the fire with the objective of destroying evidence. The pathologist can easily decide whether the victim of

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a fire was alive or dead when the fire started. No signs of inhaled smoke or flakes of soot found in the respiratory organs suggest that the person was dead before the fire. Unburned skin may be found underneath a burned body that escaped burning. Tight fitting clothing may also protect the skin from the fire. In such places signs of external violence may show clearly. Traces of blood may be found on unburned portions of clothing under the body. Uninjured parts of the skin around the wrists and ankles may indicate that the victim was bound before the start of the fire. A ligature around the neck, destroyed in the fire, may leave a distinct strangling groove.

Death by Freezing

Freezing to death does not as a rule produce any distinguishable injuries or changes in the body. At the autopsy, red spots may possibly be observed on those parts of the body where livid stains occur more rarely, e.g., the ears, tip of the nose, fingers, and toes. As a rule, only weak, helpless, insufficiently clothed, or drunken persons freeze to death.

Freezing to death can occur as the result of criminal actions, e.g., exposure of newborn or delicate children. A person who has been rendered helpless by an assault can also freeze to death. Persons who have died from freezing are occasionally found more or less undressed. This condition naturally gives rise to suspicions of murder. However, sometimes, at an advanced state of freezing, the victim gets a sensation of heat, which may explain this action.

Death by Poisoning

The determination of death by poisoning is frequently a joint effort on the part of the forensic pathologist and the forensic toxicologist. Only in certain instances will the investigating officer find the presence of physical evidence at the crime scene that indicates the death was caused by the ingestion of some poisonous substance.

Physical evidence located at the crime scene and noted upon gross examination of the deceased may sometimes be indicative of poisoning. Evidence such as drugs, narcotic paraphernalia, markings on the body, or the presence of acids or caustic substances may give an initial basis for forming an opinion about the case.

Corrosion around the mouth and face may be the result of consumption of acids or caustic chemicals such as hydrochloric acid, sulfuric acid, or lye. Odors of ammonia or burned almonds, or an odor associated with cyanides, can indicate certain poisons. In cyanide poisoning, lividity is a reddish color.

Certain drugs, such as opium alkaloids and nicotine, cause contraction of the pupils, while others such as atropine (belladonna) produce dilation.

In death from subacute and chronic arsenic poisoning a large quantity of thin stool resembling rice, often containing blood, may be found. Considerable excretion is also usual in the later stages of poisoning from corrosive sublimate or lead salts.

Strychnine causes convulsions; the corners of the mouth are drawn up and the face is fixed in a grin; the arms and legs are drawn together and the back is severely bent backward from contraction of the muscles.

Different colored materials in the vomit can give clues to the type of poisoning. Brown material resembling coffee grounds indicates poisoning with strong alkalis such as sodium or potassium hydroxide; yellow indicates nitric and chromic acids; blue-green, copper

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sulfate; black, sulfuric acid; and brown-green, hydrochloric acid. A sharp-smelling vomit indicates poisoning with ammonia or acetic acid.

Murders by using a poison that must be taken internally to be effective are not numerous. Generally murder by poison is committed only within a family or close group. In such cases, the criminal generally uses some poison that will not arouse suspicion from its color, odor, or taste. Murder or attempted murder by the use of poisonous gas occurs occasionally, e.g., carbon monoxide poisoning.

The police officer should know that, in a case of death from poisoning, only the investigation at the scene and examination of witnesses could decide whether a case is murder, suicide, or accident. The autopsy decides only the type and quantity of poison used.

It is not possible to go into a detailed description of different poisons and their actions. The boundary between poisonous and nonpoisonous substances is indefinite. A number of substances normally present in food can cause death by poisoning when they are taken in large amounts. Thus there is a case where the consumption of 13 ounces of table salt caused the death of an adult.

A number of poisons should be mentioned, including those with a powerful action and those responsible for most cases of poisoning:

- **Gaseous and liquid poisons.** Some of the more common of the thousands of these types of poisons are carbon monoxide, hydrogen cyanide, freon, methanol, toluene, benzene, gasoline, and chloroform.
- **Heavy metals and other inorganic poisons.** Compounds and salts of antimony, arsenic, barium, chromium, lead, mercury, and thallium; strong inorganic acids and bases such as hydrochloric acid, nitric acid, sulfuric acid, sodium hydroxide, potassium hydroxide, and ammonia.
- **Ethical, over-the-counter, and illicit drugs.** Ethyl alcohol; barbiturates; heroin; synthetically produced opiates, e.g., methadone; phencyclidine (PCP); minor tranquilizers such as Valium, Librium, meprobamate and over-the-counter medication when taken in excess. These drugs may be found in combination with each other and with alcohol.
- **Other vegetable and animal poisons.** Atropine, cocaine, nicotine, scopolamine, strychnine, and snake poisons.
- **Bacterial poisons and food poisoning (botulism)**.

The determination of poisoning as the cause of death can be made only by autopsy and chemical analysis. In a number of cases of poisoning, however, certain details in the appearance of the dead person or special circumstances in connection with the death may give some indication. The police officer that investigates the scene of a fatal poisoning can greatly assist the pathologist by recovering any evidence of poisoning.

The most usual indications are, first, residual poison in the form of tablets, powder, or residues in medicine bottles and, second, powder wrappings, boxes, tubes, ampoules, vials, and other containers. All such clues should be recovered and each one packed separately in a tube or envelope. When the dead person is lying in bed, the bedclothes must be examined very carefully because the poison may quite possibly have been in the form of powder and any that was spilled difficult to detect.

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All medicine bottles and tubes, including empty ones, should be kept, even if the stated contents are considered to be harmless. An apparently empty bottle may contain traces of powder, which can be identified by microchemical methods. The report of the investigation must state where such objects were found. Prescriptions can be useful guides for the pathologist.

Among the most important evidence in poisoning are cups, glasses, and other containers found in the immediate vicinity of the deceased, or in such places and under such conditions that they can be placed in direct relation to the death. If liquids left in a container are found, they should be transferred to an absolutely clean bottle that is then sealed. When a container holds merely sediment or undissolved residues, it should be wrapped in clean paper or, preferably, in a plastic bag. If finger- or palm prints are on it, these must be preserved. Spilled liquids can be collected by means of a filter paper, which is then placed in a clean glass jar and well sealed.

When food poisoning is suspected, or it is possible that dishes may have conveyed the poison, the dishes used should be collected and packed in a suitable manner. Food dishes and remains of food are packed in a clean, well-sealed glass jar. If such clues are not sent immediately to a public health laboratory, they should be kept in a refrigerator. If there is any suspicion of crime, remains of food should be looked for, also outdoors in garbage cans, compost heaps, the ground, and other such places.

Any hypodermic syringes found should be recovered and kept in such a way that they cannot become contaminated and the contents cannot run out or be pressed out. The needle of the syringe can be conveniently stuck in a cork to prevent its breaking. Finger- or palm prints on the syringe must be preserved. When hypodermic syringes are found, ampoules and vials should be looked for in the vicinity.

Vomit, saliva, and mucous on or around the dead person may contain traces of poison and must be kept. Suspected stains on clothing and bed clothes are preserved by spreading each of the articles out on clean wrapping paper and rolling them separately in the paper. Stains of urine and feces can sometimes give the pathologist a guide in making a decision and should therefore be kept.

Cases of poisoning with methyl alcohol occur at times. It can usually be assumed that other persons are involved, so bottles and drinking vessels should be examined for possible finger- and palm prints.

Chronic alcohol poisoning can give rise to sudden death, especially after bodily strain. In acute alcoholism, death occurs when the concentration of alcohol in the blood reaches 0.4 to 0.6 g%. However, the alcoholic subject can provoke sudden death through various strokes of misfortune in a number of ways (drowning, falling, traffic accidents, freezing, suffocation from vomit that cannot be ejected, gagging from food in the windpipe). It has often happened that an alcoholic subject, while incapacitated, has died because of falling asleep in a position that made breathing difficult.

If the pathologist is present at an investigation, he or she will decide which evidence should be collected; otherwise the investigating police officer should keep everything that might be suspected of being poison evidence and should subsequently submit it to the pathologist or toxicologist.

The presence of certain poisons in the human body can sometimes be confirmed a long time after death. Metallic poisons do not disappear with putrefaction. Arsenic can be detected in hair and bony parts hundreds of years after death; lead also remains for a long time in the bone tissues. Scopolomine, atropine, strychnine, and morphine can be detected

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after several years; carbon monoxide poisoning can be detected up to 6 months after death. Potassium cyanide is decomposed during putrefaction. Hydrocyanic acid and phosphorus remain for only a short time. Hypnotics are decomposed and disappear very quickly — some even in the time that elapses between administration and the occurrence of death. An exception is barbitone (veronal), which can be detected in the body 18 months after death. In cases of exhuming a body of a person suspected to have died through poisoning from metallic poisons (especially arsenic), samples of the soil from the grave should always be taken because the soil may contain the poison.

Carbon Monoxide Poisoning

Carbon monoxide is always produced when the combustion of carbonaceous matter is incomplete. It is a normal constituent of smoke and explosion gases and also occurs in mine gases, natural gas, and the like.

Carbon monoxide is a colorless and very poisonous gas with no odor or taste. The minimum concentration that can be injurious to human beings is 0.01 vol%, while 0.2 vol% is dangerous to life. Continued exposure to such an atmosphere can produce death within 1 hour. If the concentration increases to 0.5 vol% or more, then unconsciousness ensues after a couple of minutes and death follows quickly. With higher concentrations, unconsciousness comes on like a blow. Chronic poisoning by carbon monoxide is quite common, often due to prolonged exposure in shops, garages, traffic tunnels, and streets with high buildings and very heavy motor traffic.

The danger from carbon monoxide is due to the fact that the senses do not give warning in time. With acute carbon monoxide poisoning there is a headache, faintness, and nausea, with flickers before the eyes. This usually is regarded as a temporary indisposition, so the individual in question may make the greatest mistake possible under the circumstances, that of lying down. Gradually, the person becomes sleepy and confused, and the limbs become numb. If the person finally begins to realize the danger, it is usually too late because the body is so weak that the poisoned victim cannot move to safety. In many cases of carbon monoxide poisoning, the victim is found close to a door or window, but was unable to open it or did not think to break the glass.

In cases of carbon monoxide poisoning, it is possible that the death was murder. The investigating officer should therefore not treat the investigation too casually. To decide on suicide or accident immediately is wrong. The case should be considered suspicious from the start and treated accordingly. The analysis of the situation and the result of the investigation must determine whether criminal action should be taken into account. At the autopsy the pathologist can determine only the cause of death.

Carbon monoxide poisoning from exhaust gases of internal combustion motors can occur when the engine of a vehicle is started up and allowed to run for a while in a garage with bad ventilation. Suicide may be committed in this way.

Because of the variety of chemical substances that can be fatal, the determination of the cause of death in suspected poisoning cases is no easy task. Toxicologists play a key role in these types of cases. In some instances the problem is compounded because the human body is able to metabolize the poison into another related substance, or metabolite. Other problems, e.g., the small concentration of the poison in the body or the metabolite being naturally present, sometimes make these tests difficult.

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Rape–Homicide and Sexual Assault-Related Murders

Rape-homicides are murders committed in connection with rape and can be included with murders involving other sexual acts such as sodomy or anal intercourse. The methods employed in the investigation of such murders are in general the same as those techniques used in the investigation of an "ordinary" murder or suspicious death. The injuries found on the victim are often similar to those encountered in rape investigations, such as bruises on the arms and shoulders caused by forcibly holding down the victim, ligature marks on the wrists if the victim was tied, bruises on the back and buttocks caused by forcing the victim on the ground, and marks on the insides of the thighs and knees, and around the genitalia. Physical evidence such as seminal fluid, hair, blood, skin and blood found under the victim's fingernails, etc. may also be present. Trace evidence found on the victim's clothing might also be noted. The presence of alcohol or drugs should be determined from toxicological analyses.

The investigator should understand that the sexual aspects of these types of murders might manifest themselves in different and sometimes bizarre ways. Thus, sadism and other forms of sexual perversion may lead the inexperienced investigator to assume that a crime other than a sex-related murder is being investigated. Indications such as feces or urine discovered at the scene of a murder may point to a sex-related murder. Sadistic acts such as mutilation of the body and, particularly, the sex organs and breasts, and violent injuries such as biting, strangulation, and multiple stab wounds are especially significant and strongly suggest this type of murder.

In investigating the crime scene, one should look for signs of a struggle. Evidence such as marks on the ground, pieces of torn clothing, fragments of textiles, torn-off buttons, blood, semen, and the like should be searched for and collected. Specimens of sand, soil, vegetation, and other materials should be collected for comparison with debris found on the suspect's clothing.

When a suspect is apprehended, the clothing and body should be examined immediately. Scratch marks on the hands and arms, on the face, bite marks, torn clothing, soiled clothing, hair, and blood may be important evidence.

A suicidal hanging is frequently associated with sexual homicide; for example, the victim may be dressed in clothing of the opposite sex (typically a man in women's clothing) or have pornographic literature. Other signs, such as loosely binding the hands or legs and binding the genitals, may be noted.

Infanticide and Child Abuse

Homicide investigations of newborn and young children involve circumstances different from adult cases. The type of injuries causing death in infants and children are often nonfatal to adults. Often the abandoned child has no means of identification. In cases resulting in death in the home, the crime scene may show little or no physical evidence to associate the injuries with the victim. Finally, when the young victim of beating or neglect is brought to the emergency room for treatment, the child is almost always unable to communicate the cause of the injuries. These are some of the problems to be addressed in children's murder investigations.

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Figure 16.26 (A color version of this figure follows page 256.) A murder case showing sex-related mutilation. *(Los Angeles County Sheriff's Department.)*

In cases of newborn death, the pathologist is required to determine whether the child was viable, that is, capable of living. The infant is considered to be viable when it has attained a stage of development such that it would remain alive without any special care, e.g., in an incubator. Babies with a length of 10 to 16 inches can certainly be born alive, but as a rule are considered not to have reached such a stage of development that they can continue to live.

Infanticide, or killing a newborn child, can be committed in a variety of ways such as intentional neglect, killing with a weapon, suffocation, forcing objects into the nose or mouth, or by drowning.

Intentional neglect occurs when the parents fail to care for the child immediately after birth, in spite of being able to do so. Death may result from exposure, dehydration, or

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starvation. Heat regulation in the body of a newborn can be a significant factor in exposure-related deaths because the body temperature of a baby can drop rapidly.

Abandonment of the newborn child poses an additional problem. The child may be left without any means of identification. When an infant is left wrapped only in a blanket or even without any clothes, it is frequently impossible to discover evidence to determine the mother. Killing with a weapon may be carried out with blunt objects with the intent to injure the head or by striking the head against some hard object. Stabbing is another means sometimes used in infanticide.

Strangulation is another possible cause of death; manual strangling leaves injuries and sometimes scratch marks on the neck. Suffocation can be caused by placing a pillow on or using a hand to cover the mouth or nose. If the hand is used, scratch marks may be found on the face. It should be noted, however, that suffocation may be accidental and caused by the infant lying face down on soft bedding. Suffocation may also be caused by insertion of objects into the mouth. Items such as cotton inserted into the mouth may be the cause of death.

The so-called battered child syndrome is another area in deaths of children. Frequent beatings and cruel treatment as a means of punishment or discipline sometimes result in deaths of children. Poisoning, starvation, severe beatings, and scalding in very hot water are all means of injury and often death.

Examination by a pediatrician is required in suspected child abuse cases. Often, the child is taken to the doctor or hospital emergency room and the parent may claim that the injury was the result of a fall or other unintentional injury. Careful examination of the injuries may show them to be inconsistent with the "accident" described. Also, x-rays may show several broken and healed bones characteristic of repeated and severe beating.

Trunk Murder, Dismemberment of the Body

Trunk murder is the name commonly used to describe murders in which the criminal, in order to dispose of the body of the victim, places it in a trunk, chest, large suitcase, box, or similar container, which is then concealed or carried away. Even more commonly the victim is placed in a sack or covered with a blanket, clothing, or a tarpaulin. This crime is often associated with cutting up the body (Figure 16.27).

Dismemberment of a dead body may be offensive or defensive. The former is usually conditioned by passion and can be regarded as a form of sadism. A criminal who wants to conceal the body or to make it unrecognizable employs the latter. The method used may give information regarding occupational experience (butcher or person with anatomical knowledge), while the surfaces of the wounds can indicate the implements used (knife, ax, saw). Dust and dirt from the body can, in favorable cases, give information of local conditions where the dismemberment was carried out. The murderer may conceal parts of the body at different places over a considerable area, with the object of making identification of the victim difficult or impossible or may attempt to destroy the body, for example, in an acid bath or by burning.

Frequently, the place where the body was found is not the same as the scene of the crime. If the murdered person is unknown, success in the search for the scene of the crime depends largely on the possibility of being able to determine the origin of the containers or wrapping around the body or parts of the body. The first step is to determine if labels, stamps, or

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Figure 16.27 The body was discovered in a suitcase in the trunk of an abandoned car in a parking lot. The original condition of the body in the suitcase (A) and the deterioration of the face (B) are shown. *(Los Angeles County Sheriff's Department.)*

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writing can throw any light on their origin. These examinations involve such delicate procedures that they should be entrusted to an expert from the beginning. The crime scene investigator's preliminary examination should therefore not become too extensive.

Dirt or dust present in the wrapping may give direct information regarding what had been in it before. Fingerprints, hair, and other traces of the criminal should be looked for. When looking for fingerprints, no development media should be used until the laboratory expert has completed the examination. Bodies or parts of bodies that are found enclosed in a package are generally wrapped in a large quantity of paper, scraps of clothing, plastic bags, etc. — obviously in order to prevent blood, other liquid, or odor from betraying the contents. The possibility that the fingerprints of the murderer will be found in blood or blood serum should be considered. Objects used to wrap the body or parts of the body can also be a useful guide in searching for the actual scene of the crime.

Serial Murders

Serial murders are distinguished from multiple murders in that the latter are committed at about the same time and the victims are in some way connected with one another, e.g., through family ties, socially, or living close by. Serial murders occur over a period of time, sometimes years, and often over large geographic areas. Probably the most celebrated serial murderer in history was the infamous Jack the Ripper who terrorized London in the 1880s. Some infamous modern cases have occurred in New York, Los Angeles, Atlanta, Washington, and Florida. Serial murders are among the most difficult types of homicides to investigate because of their complexity and a component unique to this type of crime: public alarm (Figure 16.28, Figure 16.29, and Figure 16.30).

Serial murders follow an almost predictable course. Investigators discover that the M. O. of a case they are working on has similarities to other cases. As the investigation progresses, investigators from a variety of police agencies may become involved in the investigation, as may others, i.e., criminalists, pathologists, and so on. Once it becomes clear that the case involves a serial murder, communication with all others in the total investigation is imperative. Principal investigators, forensic scientists and others who must take an active role in the case should be identified and should coordinate the investigation from this point on. All suspected future cases should be reviewed and, if possible, the crime scenes visited. Because of the delicate balance between the public's right to know and the possibility of public hysteria, all press contacts should be handled from a centralized source and specific details about the case should be withheld from the public so as not to hamper the investigation.

Once the news story breaks, enormous demands will be placed upon those responsible for the investigation. Here "cool heads" must reign. Doubtless, there will be tremendous public pressure to solve the case. Investigators will be deluged with telephone calls, yielding thousands of pieces of information (much of which will be of little value). "Copy cat" cases, those with certain similarities to the serial murders, may develop.

Solving cases of the size and scope of a serial murder investigation usually involves little magic; hard work, long hours and attention to details solve these cases. The ability to sort through mountains of information, recognize behavioral patterns, and, above all, coordinate the efforts of scores of people associated with the various elements of the case makes for a successful investigator.

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Figure 16.28 In one of California's most celebrated serial murder cases, an individual dubbed the "Night Stalker" by the press terrorized the Los Angeles area. Before his reign of terror ended, at least 13 people were viciously murdered and numerous others were assaulted. His murder spree ranged from San Francisco to Orange County. A regional task force was lead by detectives from the Los Angeles County Sheriff's Department, Homicide Bureau. Evidence of a satanic link — upside-down pentagrams (A, B) — and an AC/DC cap were noted at early crime scenes and attributed to the assailant. After his capture and during his trial, upside-down pentagrams were found on the dashboard of his car and in his holding cell. Based on a latent fingerprint from a vehicle used by the Night Stalker in an assault in Orange County, California, he was identified as Richard Ramirez on August 30, 1985. A mug shot photograph was released to the press the following morning. That same morning, as newspapers were being distributed, Ramirez was on a bus returning to Los Angeles from Arizona. Within hours he was spotted and captured by citizens in East Los Angeles. Once in custody, he was positively identified as Richard Ramirez, alias the Night Stalker. Four years elapsed before Richard Ramirez was found guilty of all counts brought against him, which included 13 murders and 30 other felonies. He was sentenced to die in the California gas chamber. *(Los Angeles County Sheriff's Department.)*

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Figure 16.28 (continued)

One final talent for the investigator to master is worth mentioning: leadership. This know-how plays a part in serial murder investigations and may also affect other types of police investigations. The detective is ultimately responsible for running a police investigation. He or she must rely on a host of professionals within the criminal justice system. Interpersonal skills really make a difference. Learning how to ask rather than demand, saying thank you for some extra effort, and establishing good, long-term cooperative working relationships distinguish the great investigator from the adequate one.

Homicide investigation brings together nearly all the skills and principles discussed throughout this text. It requires the coordination and cooperation of many disciplines and the capability of the investigator to assimilate large amounts of information. The skills needed to process the crime scene and the ability to recognize, collect, and preserve physical evidence are crucial. A mastery of the techniques of crime scene investigation is essential to modern law enforcement.

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Figure 16.29 (See facing page.)

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Figure 16.29 (continued) The crime scenes attributed to the Night Stalker started to show a grisly pattern: restraints (i.e., cords, belts, handcuffs, and thumb cuffs) were found at many scenes, as well as various tools that were used to bludgeon his victims. A characteristic shoe impression linked several crime scenes. The unusual shoe pattern, identified as that of an Avia brand, was seen in soil, blood, and dust. The impressions were preserved through the use of photography, plaster casting (A), and tape lifts. The shoe impressions were compared and found to have similar class characteristics to the Avia aerobic, size 11 1/2 (B). After consultation with the owner of the Avia company, it was determined that only one pair of size 11 1/2 shoes was distributed in the Los Angeles area, of 97 pairs in the entire state. The shoes were never recovered. *(Los Angeles County Sheriff's Department.)*

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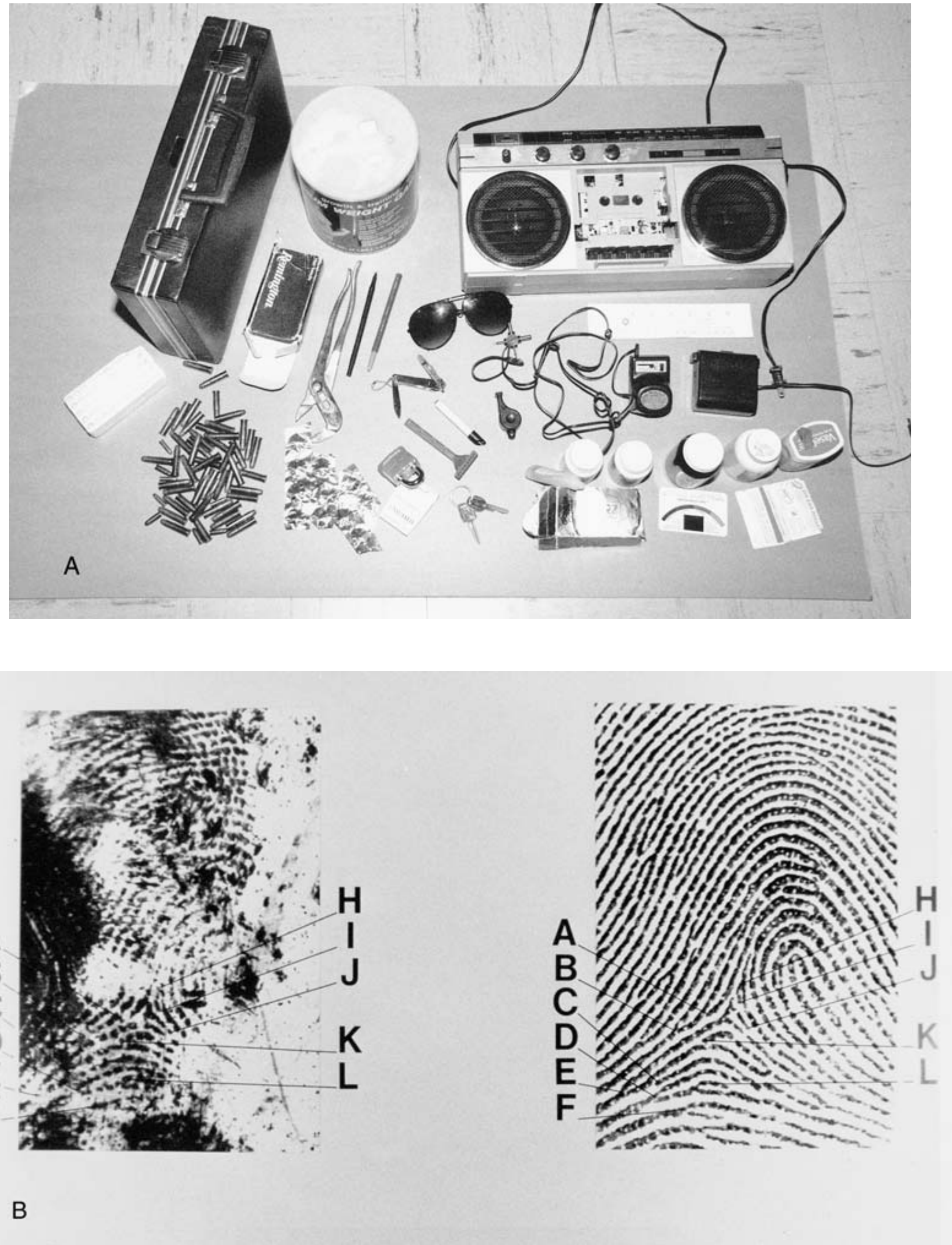

Figure 16.30 The Firearms and Latent Print sections of the Los Angeles County Sheriff's Department, Scientific Services Bureau, played an important part in Ramirez's conviction. Rifling marks from bullets recovered at different scenes were compared. It was established that they were fired from the same handgun. This substantiated the initial hypothesis that the same individual committed the crimes. On the day of his arrest, items belonging to Ramirez were seized from a local bus depot locker (A). Among these items were a yellow flashlight and live rounds of ammunition. A latent fingerprint (B) on the flashlight was identified as belonging to Ramirez, thereby linking him to the recovered property. More important, the live rounds exhibited a magazine signature identical to markings on expended cartridges found at four of the Night Stalker crime scenes. (C, D). *(Los Angeles County Sheriff's Department.)*

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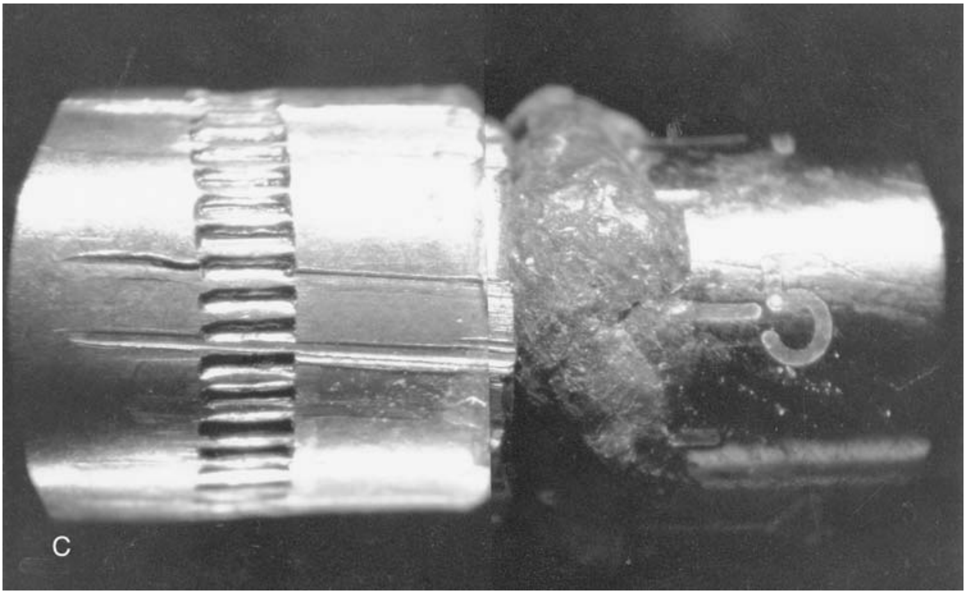

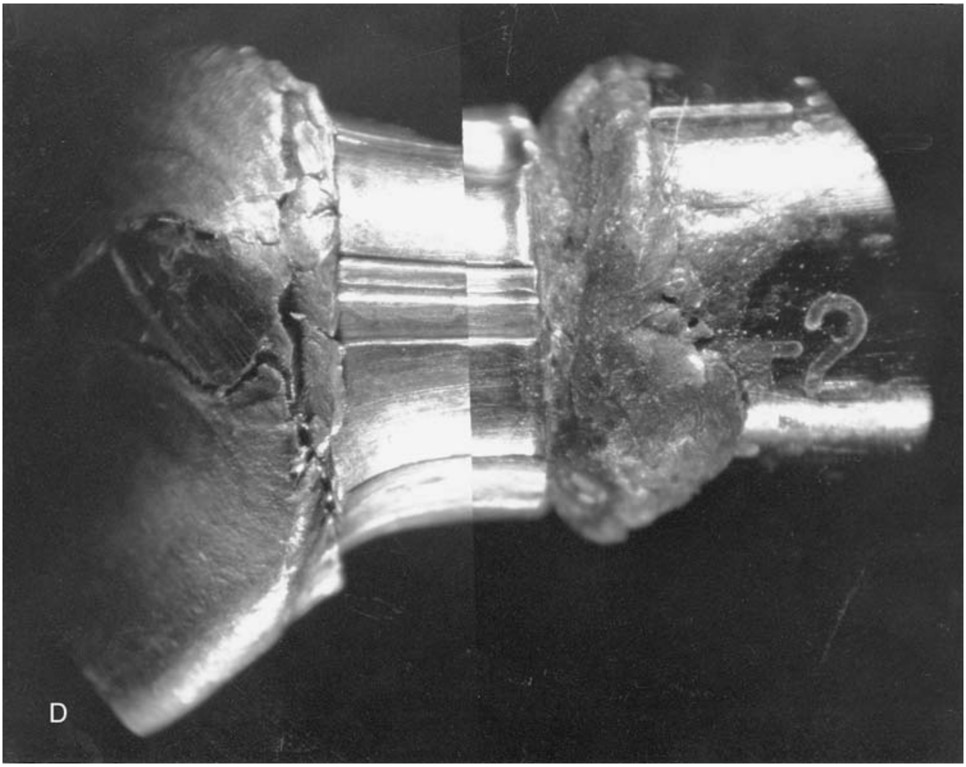

Figure 16.30 (continued)

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